Journal of the United States association of charcoal iron workers

United States Association of Charcoal Iron ...

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JOURNAL

OF THE

UNITED STATES ASSOCIATION
OF
Charcoal Iron Workers.

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1886.

UNITED STATES ASSOCIATION

—OF—

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OF

CHARCOAL IRON WORKERS.

Devoted to discussing and illustrating improvements in iron metallurgy, or in the manufacture of charcoal.

It is mailed, post paid, to each MEMBER and ASSOCIATE of the
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Edited by JOHN BIRKINBINE, Secretary,
No. 152 South Fourth Street, Philadelphia, Pa.

ARTICLE V.—Constitution of the United States Association of Charcoal Iron Workers.

Any person practically engaged, or interested, by reason of capital invested, in making or using pig-iron or blooms made with charcoal may become a MEMBER of the Association by paying an annual fee of five dollars ($5.) *Provided,* That each iron works represented shall pay not less than ten dollars ($10) per annum into the treasury.

Persons not engaged in making or using charcoal pig-iron or blooms may become ASSOCIATES, without the right to vote or hold office, upon the payment of an annual fee of five dollars ($5) each. All fees to be due when the membership is applied for, and thereafter on the first day of October in each year, being in advance.

All communications should be addressed to the Secretary of the Association.

Heroic Treatment for Blast Furnaces.

[As an addition to the information published in the JOURNAL, Vol. VI, p. 125–135, concerning the treatment of blast furnaces, when chilled or scaffolded, we present the following extracts from a paper entitled "A Chilled Blast Furnace Hearth," by James Gayley, read at the meeting of the American Institute of Mining Engineers, at the Pittsburgh meeting, February, 1886.]

The removal of obstructions in furnace-hearths by opening up tuyeres and notches with sledges and chipping-bars was tedious and often futile. The use of the steam-drill, which has been frequently applied, was much preferable, since it possessed the valuable quality of never getting tired; but even with this powerful help, many furnaces have had to be shoveled out. All other methods, however, have been superseded, in point of speed and reliability, by the introduction of the hydro-carbon blow-pipe,* and, through the use of this device, the time has arrived when the shoveling-out of stock and the blasting of salamander, on account of an obstruction, can be done away, and the term "chilled up" should become obsolete.

* * * In many cases, where the hearth is partly chilled or filled with mushy cinder, a good charge of dynamite will give quick relief. But if there is, instead, a solid mass extending above the cooling-blocks, the safest and quickest way is to melt it out by means of the blow-pipe—and preferably the one using oil; since, by this plan, the material is heated to the melting point in about one quarter of the time that would be required with coke and hot-blast. There is, moreover, the further advantage that the oil blow-pipe is able to work effectively in a smaller space.

* * * The nature of the material forming the obstruction has necessarily much to do with the rapidity of its melting. When there is a large amount of cinder (which is usually the case) and coke or coal imbedded in the mass, the blow-pipe will cut very rapidly and keep all hands busy removing the cinder. After this rapid melting has commenced, a very small quantity of oil will be

required. But as the material we had to deal with was composed largely of iron, progress was comparatively slow. The small amount of cinder present had a tendency to remain in a pasty condition in the cavity for a long time, interfering with the melting; and in flowing out, it would chill around the mouth of the opening. To obviate this, some salt was thrown in from time to time, which made the mass very fluid. The use of some of the fusible salts in connection with the blow-pipe is of great advantage; and, if fed into the air-pipe and forced out with the blast, they will be more evenly distributed and will prove more affective.

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* *Vide* JOURNAL Vol. VI, p. 126.

The history of the case to which I wish to call attention is as follows:

On December 31, 1885, on account of labor troubles, all the furnaces at the Edgar Thomson works had to be banked very suddenly. It was not until January 20, 1886, that matters were so arranged as to allow of starting up.

* * *

When we opened furnace E, on January 21, everything was found in first-class condition. There was plenty of bright coke at all the tuyeres and at the cinder-notch. At 2.P. M., we turned the blast on, and she started off in good shape. The stoves had been fired with wood, and showed a temperature of 500° F. In one hour after starting, a mushy cinder appeared at the tuyeres. The notch was opened (the cinder-tuyere having been left out) and a good-sized flush of unseparated cinder and iron was obtained. A bar was driven in after stopping up, to insure getting the hole the next time. An hour and a half later, a second flush was made, of about the same character as the other, but larger in quantity. A bar was again driven in, and everything went smoothly for two hours more, when, in trying to pull the bar out, it broke off. After several unsuccessful attempts to drive another one through, the iron cooler, which holds the bronze cinder-tuyere, was taken out to permit getting a hole higher up. The material here was quite hot, and we were making good progress, when a heavy slip occurred on that side of the furnace, and five minutes after, two more followed in quick succession, on the other side and the back. Cinder ran freely out of all the plug-holes and joints of pipe-connections, closing up five of the tuyeres. At No. 7 tuyere, which is to the right of the notch, a hole, about 3 inches in diameter, was cut in the goose-neck. Through this opening, a current of air was projected on the fall in front of the notch—which, with its incessant roar and the clouds of sand, hurled in every direction, made it almost impossible to accomplish anything. A temporary plug was inserted, and drilling was pushed forward as rapidly as possible by relief gangs, without, however, making much progress. The three open tuyeres were blowing through mushy material, and soon closed up. The engine was then stopped. The pressure-gauge, when last observed before stopping, showed 10 pounds, 4 pounds being the normal pressure before the slip occurred.

The belly-pipes were taken down with difficulty, as the upper half was filled with iron which had partly solidified. Only two of the tuyeres could be taken out: the others were too firmly imbedded in iron.

A careful examination was made of the condition of each tuyere with respect to obtaining an entrance; but of the whole number—eight tuyeres—only one showed any cinder, and there it consisted simply of a shell about 2 inches thick on the face of the iron.

Arrangements were then made to get the blow-pipes at work. Two were fitted up and started by noon on the 22d, one working in the cinder-notch, the other in No. 6 tuyere, to the left. In a short time, they commenced to melt; and as the cavity increased in size, the progress was more rapid. For a distance of 18 inches to 2 feet toward the center of the hearth, the material was quite hard and consisted mainly of iron. Beyond that it became softer and showed more cinder. In six hours after we got fairly started, a cavity was melted out, in size about 6 feet long, 5 feet wide, and 4 feet high—or 3 feet above the center of the cinder-notch. The crust was then penetrated, and a large quantity of good, hot coke fell through. A tuyere was put in, the cinder-notch closed, and we started off again in a legitimate manner, having no further trouble with either tuyere or cinder-notch from that time on. In opening the tuyeres, the bronze cooler, which holds them, was protected by packing with clay, and by making a channel from the butt of the tuyere outward with hexagon bricks, having a 6-inch opening. Even in this small space, the blow-pipe worked very effectively.

The tapping-hole was opened by the same means; but we were obliged to burn it out several times before we could retain it permanently. In burning out at this place, the usual plan is. to keep on melting until the iron breaks through. This happens, as a rule, when least expected, and frequently just after a cast has been made over the fall, and the hearth has been left comparatively dry. Instead of this plan of burning out, it will be found that when the blow-pipe has melted in a reasonable distance, and the cavity is well heated up, a tapping-bar can usually be driven through without much trouble. By doing this, we were able to save several hours' tedious melting, and could cast with a hearth full of cinder and iron, which is very desirable. In the space of six days after the accident, all the tuyeres were at work: and the furnace gave us no further trouble.

The most interesting feature presented by the obstruction was the presence of such a large quantity of iron. In the material melted from the cinder-notch, the proportion, as far as we could judge, varied from 60 to 80 per cent. At all the tuyeres, which were opened by the blow-pipe, fully 80 per cent. of iron was found; at no time did the proportion of cinder exceed 40 per cent., and it was generally less. The only explanation I can offer for this condition of the hearth is, that the several slips brought down a large amount of reduced ore in a state of fine sub-division, which, absorbing all the heat of the hearth in melting, produced the sudden chilling. Judging from the quantity of cinder that ran out of the plug-holes and pipe-joints after the slip occurred, it seems to have been largely squeezed out in that way.

While managing furnaces, I often observed that, when a slip occurred after a period of regular working, the next cast of iron was larger than usual. Particularly was this the case when the heat in the hearth was sufficient to melt the material brought down. If the temperature is low, or an unusually large quantity of the material is present, it will become thick and mushy, and part of it, sometimes, will remain as a powder. Our practice was to cast as quickly as possible, so as to clear the hearth and bring fresh coke in front of the tuyeres; and we generally got 50 per cent. more tonnage than we would have obtained under ordinary working. Indeed, it seemed a mystery, sometimes, where such a large quantity of iron could come from. * * * * *

Ore Washer and Separator at Copake Iron Works, New York.

[Read at the sixth annual meeting of the United States Association of Charcoal Iron Workers.*]

By WM. A. MILES.

The general form of ore washer illustrated is familiar to most of the members of the Association who mine brown hematite ores, and is known to them as the Bradford washer. It consists of a series of iron staves, properly secured to spiders, forming a cylinder with conical end revolving by means of gearing, and to which the ore to be washed is fed from a chute which also carries an abundant stream of water. The staves are perforated with small holes, and have on their inner faces series of blades, or cutters, to break up clay lumps, etc. The arrangement shown embraces the latest inventions of the originator of this form of washer, and some modifications by the writer.

As will be seen, the staves are secured to the heads by grooved flanges, and are held together by bands; and the cylinder is immersed in a wooden trough, or box, in which water is maintained at a desired elevation by means of a gate. A large opening in the receiving head permits of feeding wash and lump ore up to eight inches in diameter to the cylinder, where it is carried around by the rotary motion, the lump ore assisting the blades to break the masses of clay, or ocher, containing fine ore, and the water entering with the ore carrying the mud and fine ore through the perforations in the plate. The blades force the ore, as washed, towards the discharge head, where it is lifted by perforated wings into a rinsing chamber, there meeting a stream of clear water, which cleans it of adhering mud, and carries this mud back into the washer, this water assisting in softening lumps. The rinsing chamber forms a connection between the washer and the separator, and is encircled by a gear which engages with a pinion, thus giving the rotary motion to both the washer and the separator.

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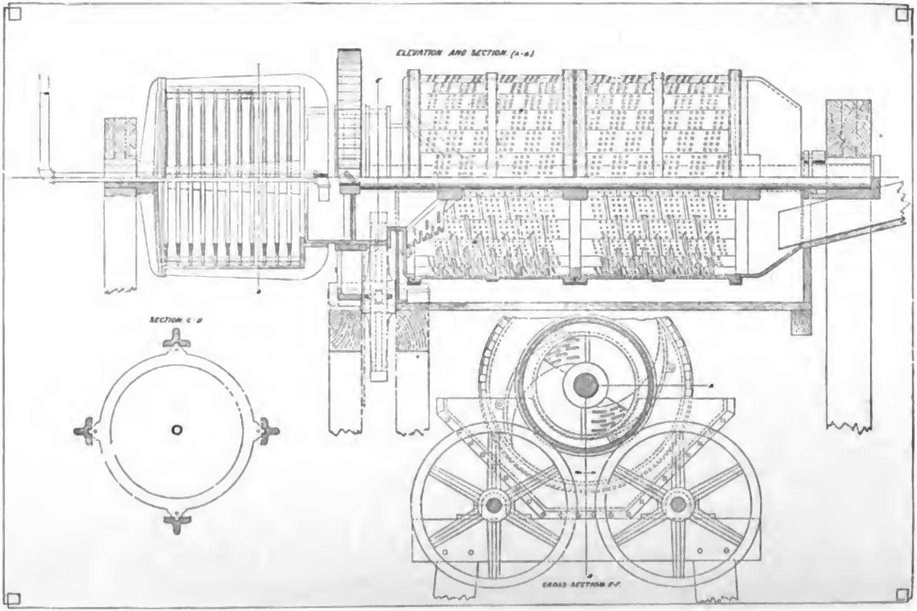
*This paper should have appeared at an earlier date, but, owing to absence of the writer and a defective cut, it was necessarily postponed until the present time.—ED.


ELEVATION AND SECTION (A-B)
SECTION C-D
CROSS SECTION E-F

Trunnions at the receiving end of the washer and at the discharge end of the separator sustain the extremities of the apparatus, and carrier wheels working in a groove of the rinsing chamber sustain the central portion.

The separator consists of a series of rings held in a suitable frame and spaced by means of bolts and thimbles, the bolts uniting spiders at either end; the spaces are conveniently altered by withdrawing the bolts and changing the length of the thimbles. The ore from the rinsing chamber passes through this separator, and all sizes small enough to pass through the spaces between the rings drop, while the larger pieces are carried to the end of the separator.

The water which is discharged from the wooden trough, carrying fine ore, passes into a revolving screen which saves all ore which will not pass through a sieve of No. 10 mesh.

At the Copake iron works, New York, we have, in a washer and separator similar to the illustration, prepared 20 tons of ore per hour from material carrying 20 per cent. of ocher, delivering the washed ore at from $\frac{1}{4}$ inch to $1\frac{1}{2}$ inches diameter, and separating the larger lumps for crushing.

The principal dimensions of this washer and separator are as follows:

Washer proper, 52 inches in diameter and 8 feet in length; the holes in the staves are $\frac{1}{4}$ inch diameter.

Gear, 62 inches in diameter, with an opening in what would be the hub of 38 inches, forming the rinsing chamber.

Rinser, 38 inches in diameter and 20 inches long.

Separator, 30 inches in diameter; inside length, 3 feet.

Length from trunnion of washer to trunnion of separator, 14 feet.

The illustration is on a scale of about 1 to 40, and exhibits a longitudinal view of the washer, rinser, and separator, the upper half being in elevation and the lower half in section on the line *AB*. The sectional portion shows the positions of perforations in and blades on the staves, and also elevating wings in the washer; it also shows the rings, bolts, and thimbles of the separator. From this view, which occupies the upper part of the plate, the position of gear wheel, trunnions, etc., can be determined.

The lower portion of the plate shows a part section and elevation on line *EF*, and also a section through the separator on line

CD. The former shows the two carrier wheels, a section of the rinsing chamber, exhibiting part of elevating wings in the washer, the contour of gear wheel, and the wooden water-trough; the latter view shows the detail of construction of separator.

It is, perhaps, unnecessary to explain that the ore and water pass by the chute at the right of the illustration into the washer, where it is carried to the left by the blades and lifted into the rinser, from which it falls into the separator, the lumps too large for the space being discharged to the left.

The advantages which the arrangement, as illustrated, possess are the large openings in the receiving and discharge heads, which, by admitting lump ore to assist in breaking balls or masses of clay, or ocher, permit of using but two lengths of staves, the ordinary form of washer requiring three or four lengths. The blades, or cutters, which are triangular in form, are so placed that the ore is raised by the tapering edge, and is kept falling back upon the clay balls, reducing them rapidly in size. The perforated wings which lift the ore from the washer proper to the rinsing chamber permit the muddy water to drain from the ore before delivering it to the stream of fresh water, and this rinsing prepares the ore free from accumulations of foreign matter on the surface. The possibility of washing lumps of ordinary size and all the ore as mined (except large pieces) is a point in favor of the arrangement shown, as in former designs the heads were too small to admit these lumps. The delivery of washed lump-ore to crushers prevents waste by screening, as, practically, the mass is all ore. The value of thorough sizing will be appreciated by blast-furnace managers, particularly those who operate furnaces of moderate dimensions; and no portion of the duties of furnace managment are more important than those which pertain to the preparation of the stock which is fed to the furnace. This has been prominently brought to the notice of members of the Association by editorials, contributions, or data published in the JOURNAL, and, believing that every arrangement to accomplish economies in the manufacture of pig-iron would be acceptable to the members, this brief note upon a washer and separator (which is believed to possess merit as above specified, and, in addition, to operate with less power than other forms,) is presented.

DISCUSSION.

Mr. W. A. MILES, upon concluding his explanation of the Bradford ore washer, said, in reply to questions:

"We must wash our ore and can get any size we desire from the separator. The ore in the Salisbury region is of all sizes, from No. 10 mesh to lumps weighing 1 ton. We crush all the ore that does not pass through the separator. We can save nearly all the ore to 18 mesh, and all the ore is saved to 10 mesh. Water will not readily dissolve the ocher—it must be powdered; but when the mass is allowed to freeze, the frost will crack the ocher so that it will fall from the ore."

Mr. LOBDELL, of Delaware. We use the old-fashioned shaft-washer, called a "buddle" in south-west Virginia, and have large quantities of fine ore, but it has so much sand mixed with it that we cannot utilize it. This fine ore with the sand will analyze 33 per cent. of iron, and when separated from the sand, is the best that is in the mine. The ores of that section are mixed with clay and loam, and occur in nests and pockets. We generally have to mine 4 tons of earth to get 1 ton of washed ore. After cultivating some of our land, we scrape the surface and pass it over a screen, using the ore that will not pass through it in the furnace without washing. The ore from the deposit that has so much sand is all passed over a screen after it leaves the washer—first over one of 1¼-inch mesh and then over one of ¼-inch mesh.

Mr. JOHN BIRKINBINE, in answer to a question, stated that in the Cripple Creek region, in Virginia, the water to wash the ore must be pumped ¾ of a mile, in one case, and cited instances where all ore, clay, etc, were carried considerable distances to be washed. In that region, all the washers are wooden shafts, with blades or paddles, but in the Salisbury region, most of the washers are of the general type described by Mr. Miles, without some of the newer features.

Mr. SEYMOUR BROWNELL, of Michigan, said that, in northern Wisconsin, the ore was separated from the ocher by roasting it, when the ocher drops off. In the absence of a crusher, the iron was pounded through iron grates to get it to a uniform size. Crushing the ore saved from 30 to 40 bushels of charcoal per ton in a short stack. He roasted the ore before crushing, but at some places all the ore and flux is broken by hand.

Mr. CHARLES H. BROWN, of Tennessee. Our brown hematite ore is small; we wash it in an ordinary shaft-washer, and screen the sand from it by hand after washing—an 8-mesh screen is used. The ore yields about 40 or 42 per cent. of iron. The small ore is charged by itself. We get 1 ton of iron ore to 3 tons of dirt.

Mr. J. C. FULLER, Pennsylvania. We have been saving the fine material screened from the washed ore, at Pine Grove Furnace, and have a great deal of ore and sand mixed, which is screened by hand. The ore averages 40 per cent. of iron, and the screened ore about 30 per cent. We charge this screened ore with the other ore. The ore costs 5 cents per ton to screen, and 5 cents per ton to get it to the furnace by our cars; the pieces average about the size of buckwheat. The sand and ore are mixed about half and half before screening. We sell the sand screened from the fine ore to masons, as it makes good mortar; we get 40 cents per ton for it, and it costs 5 cents to load it. The sale of the sand pays for all work, and the small ore is free of cost to us. The ore will analyze from 30 to 32 per cent. of metallic iron. We opened a bank of ore 300 feet up the hill, and it took 8 cars of ocher and ore to give 1 car of cleaned ore; the ore, however, was very good when cleaned. A 7-inch hole was drilled down 300 feet, and when stopped, it was not at the bottom of the ore. We struck no water in drilling this hole.

Mr. LOBDELL. It is better to have the ore of uniform sizes, and I think by having it so, that we save fuel in a furnace 30 feet in height.

Mr. F. P. MILES, New York. We get our ore about the size of a hen's egg and save fuel, but, possibly, we might not save fuel if the furnace was higher.

Mr. JOS. D. POTTS. Pa. We crush our ore and limestone to the size of an egg and consider it good economy.

Mr. GEORGE H. RUSSEL, Michigan, said that his experience was almost entirely with the hard lake ores, and he thought that their better preparation and finer crushing had helped materially to better the work in the Detroit furnaces, besides lessening the amount of fuel required. These furnaces used to break the ores with a hammer, and put in pieces as large as an egg; the fuel then required was from 115 to 120 bushels of charcoal per ton of iron.

Now the ores are crushed to smaller than chestnut size, and much more attention is paid to a small uniform size. The crusher jaws are oftener replaced than formerly, as a change in the work of the furnace is quickly noticed if the ore goes in unusually coarse. Iron is now being made at Detroit on 85 bushels of charcoal per ton. All of this difference is not attributable to the better preparation of the ores, but he thought it had contributed very largely towards it.

Mr. John F. Holloway, Ohio. In furnaces, the fine ores may pack close, but the lumps would open up the charges and let the heat through; this is the case with soft ores.

Mr. Lobdell. I think, all conditions being equal, that fuel will be saved by crushing the ore to a uniform size, and that the fine ore, if any, should be charged so as to be at the outside and the coarse ore in the center of the furnace, and that the coal should not be too large. We screen all the coal and use all that will not pass through a ¾-inch mesh.

Mr. F. P. Miles. I think the blast should be increased when the furnace stack is higher, and when it is using the same kind of fuel and ore as were employed in a smaller furnace.

Mr. J. Birkinbine. In all cases, I believe it to be advantageous that the ore should be of uniform size. The Warner furnace, Tennessee, is doing very good work largely on account of the carefully prepared ore.

Flaxseed ore is used at some of the blast furnaces in eastern Wisconsin, and I do not think large lumps of any kind are valuable in a blast furnace.

The charcoal is more uniform in size in the North than in the South. In the South the charcoal is charged too large. I think the furnaces would give better results in Alabama if the charcoal was of more uniform size.

Mr. Lobdell. The pressure of the blast has an influence. We blow ¾-pound through two 4-inch tuyeres into a stack with an 8½-foot bosh by 32 feet high. The tuyeres are of bronze and the blast is cold. The tuyeres are never moved until the blast is over. We use a Root blower, No. 4, and get ¾-pound pressure with it.

Pig-iron Statistics for 1885.

In the JOURNAL, Vol. VI, pages 391 to 394, we gave the prominent features of the production of pig-iron in 1885, and promised to continue the record more in detail, which promise we now fulfil.

The production of pig-iron in 1885, classified according to the character of the fuel used, is given below, as compared with 1880 to 1884, in net tons.

FUEL USED.	1880.	1881.	1882.	1883.	1884.	1885.
Bituminous,	1,950,205	2,268,264	2,438,078	2,689,650	2,544,742	2,675,635
Anthracite,	1,807,651	1,744,462	2,042,138	1,885,596	1,586,458	1,454,390
Charcoal,	**537,558**	**638,838**	**697,906**	**571,726**	**458,418**	**399,844**
Total,	4,295,414	4,641,564	5,178,122	5,146,972	4,589,613	4,529,869

The condition of the blast furnaces and the production in each half of the year was as follows:

FUEL USED.	PRODUCTION ACCORDING TO FUEL USED.						
	BLAST FURNACE.				PRODUCTION.—TONS OF 2,000 lbs., (INCLUDES SPIEGELEISEN.)		
	In blast July 1, 1885.	DEC. 31, 1885.			First half of 1885.	Second half of 1885.	Total for 1885.
		In.	Out.	Total.			
Anthracite,	80	105	103	208	703,217	751,173	1,454,390
Charcoal,	**53**	**60**	**121**	**181**	**186,291**	**213,553**	**399,844**
Bituminous,	95	111	91	202	1,261,308	1,414,327	2,675,635
Total,	228	276	315	591	2,150,816	2,379,053	4,529,869

The total number of furnaces given in the tables as being in or out of blast at the close of 1885 was 78 less than at the close of 1884. Eighty-five of the furnaces entering into the statistics for 1884 are considered as not entitled to be longer considered statistically, having been permanently put out of blast or practically dismantled.

Pennsylvania still holds the first rank as an iron producer, having made, during 1885, 2,445,496 net tons, or 53.99 per cent. of the total output of the country; of this amount, 1,198.100 net tons were produced with bituminous fuel, 1,235,248 tons are classed as anthracite iron, and **12,148** net tons were made with charcoal.

Ohio holds second rank, having made 553,963 net tons, all having been produced with bituminous fuel except **18,018** net tons, which were charcoal iron.

Illinois ranks third, having an output of 327,977 net tons, all bituminous iron.

Alabama followed with a product of 227,438 net tons, of which **77,573** net tons were made in charcoal furnaces, the largest output ever made by this State.

Virginia, with a make of 163,782 net tons, all smelted with bituminous fuel except **12,648** net tons of charcoal iron, is closely followed by Tennessee and New York, the former having produced 130,026 net tons of iron with bituminous fuel, and **31,173** net tons with charcoal, a total of 161,199 net tons, the latter having made 145,475 net tons of iron with anthracite fuel, and **14,682** net tons with charcoal, making a total of 160,157 net tons.

Michigan's output was **143,121** net tons, all made with charcoal.

These eight States are the only ones which produced over 75,000 net tons of pig-iron in 1885.

The following table exhibits the percentage of increase or decrease in pig-iron production from 1879 to 1885, or during the existence of the United States Association of Charcoal Iron-Workers:

B.—*Percentage of Increase or Decrease.*

FUEL.	1879 over 1878.	1880 over 1879.	1881 over 1880.	1882 over 1881.	1883 over 1882.	1884 less than 1883.	1885 over or less than 1884.	1885 over 1878.
Anthracite coal,	16.5	41.9	*4	17.7	*7.66	*15.8	*8.3	33
Bituminous coal,	20.8	35.52	16.3	7.5	10.3	*5.3	5.1	124.6
Charcoal,	**22.3**	**49.79**	**18.8**	**9.25**	***18.**	***19.8**	***12.8**	**33.6**
Total,	19.1	39.8	8	11.5	6.6	*10.8	*1.3	75.8

* Decrease.

The stocks of unsold pig-iron in the hands of the manufacturers or their agents at the close of 1885, *and which was not required for the consumption of those who produced it,* amounted, according to statistics prepared by the American Iron and Steel Association, to 416,512 net tons, or 371,886 gross tons, more than half of which was charcoal pig-iron. The following table shows the stocks according to fuel used for the past six years:

	NET TONS OF 2,000 POUNDS.						
	Dec. 31, 1880.	Dec. 31, 1881.	Dec. 31, 1882	Dec 31, 1883.	Dec. 31, 1884	June 30, 1885.	Dec. 31, 1885.
Bituminous,	184 626	36.495	157, 196	171.802	191, 845	306 251	115,932
Anthracite,	175, 862	90 351	107. 259	178 020	178, 993	138. 595	68, 178
Charcoal,	**96,170**	**84,050**	**165,239**	**183,978**	**222,162**	**248,070**	**232,352**
Total,	456, 648	210, 896	429, 694	533, 800	593,000	692, 916	416, 512

The stock of charcoal pig-iron on hand at the close of the years 1880 1881, 1882, 1883, 1884, and 1885 represented the following percentages of the total production of charcoal pig-iron in the years named:

Stock at close of 1880 represented 17.8 per cent. of the year's production.
" " 1881 " 13.1 " " " "
" " 1882 " 23.6 " " " "
" " 1883 " 32.1 " " " "
" " 1884 " 48.4 " " " "
" " 1885 " 50.7 " " " "

Of the total stocks of pig-iron on hand at the dates above named, the percentages represented by charcoal iron were

Charcoal pig-iron.	**Janua-y 1, 1881, 21**	**per cent.**	**of total scock.**
	Janua'y 1, 1882, 39. 8	**"**	**"**
	January 1, 1883, 38. 4	**"**	**"**
	July 1, 1883. 27. 5	**"**	**"**
	Nov'ber 1, 1883, 33. 5	**"**	**"**
	January 1, 1884, 34. 4	**"**	**"**
	January 1, 1885, 37. 4	**"**	**"**
	January 1, 1886, 55. 8	**"**	**"**

The geographical distribution for four years of the stocks of unsold charcoal pig-iron was:

STATES.	TONS OF 2,000 POUNDS.				
	Jan. 1, 1883.	Jan. 1, 1884.	Jan. 1, 1885.	Jan. 1, 1886.	Product for the year 1885.
New England,	9 866	12. 437	11, 433	8 697	18. 809
New York,	12. 559	17, 207	17, 426	16, 539	14 682
Pennsylvania,	10 241	11, 336	14 297	13. 462	12, 148
Maryland,	5, 543	6. 399	5 734	8 762	10 432
Va., N. C., Ga., and Tex.,	19, 182	14 434	20. 326	22 510	22, 078
Alabama,	16, 622	6, 731	10. 900	10. 530	77, 573
Kentucky,	7, 264	6. 916	5 524	4 319	4,707
Tennessee,	10, 460	18. 061	19 448	17. 967	31, 173
Ohio,*	28. 314	25 221	19 441	21 412	18, 018
Michigan,	27. 073	35 678	60 715	67, 779	143, 121
Wisconsin,	5, 801	6. 340	7. 366	4 998	19, 629
Missouri,	12, 323	17. 891	24. 328	29. 373	21, 785
Pacific States,		5 327	5, 224	5, 707	5, 689
Total,	165 239	183, 978	222, 162	232, 352	458, 418
*** Hanging Rock District of Ohio,**	27, 436	24, 236	18, 726	16, 361	18, 018

In analyzing the tables, of statistics we found an extremely close relation existing between the amount of pig-iron imported into this country and the stocks in makers' hands. No one year is a fair index of this relation, but in the series of years covered by the existence of this organization we have the following statement:

YEAR.	NET TONS.	
	Foreign pig-iron imported.	Domestic pig-iron in makers' hands.
1879,	340,672	141,674
1880,	784,968	456,658
1881,	520,835	210,896
1882,	604,978	429,694
1883,	361,366	533,800
1884,	206,381	593,000
1885,	164,349	416,512
Total for seven years,	2,983,549	2,782,234
Average for seven years,	426,221	397,462

From the above, it would appear that the manufacture of pig-iron in the United States is sufficiently sensitive (notwithstanding the cumbersome character of the plant and the disposition of stocks, of ore, and fuel, etc., contracted for) to prevent over-production, but it is not able to conform itself to the surplus products of foreign countries.

The annexed statement exhibits the production of Pig-Iron according to fuel used from 1854 to 1885, both inclusive.

YEARS.	NET TONS OF 2,000 POUNDS.				PERCENTAGES OF TOTAL MAKE.		
	Anthracite.	Charcoal.	Bituminous.	Total.	Anthracite.	Charcoal.	Bituminous.
1854,	339,435	342,298	54,485	736,218	46.10	**46.49**	7.41
1855,	381,866	339,922	62,390	784,178	48.70	43.35	7.95
1856,	443,113	370,470	69,554	883,137	50.17	41.95	7.88
1857,	390,385	330,321	77,451	798,157	48.91	41.39	9.70
1858,	361,430	285,313	58,351	705,094	51.26	40.46	8.28
1859,	471,745	284,041	84,841	840,627	56.12	33.79	10.01
1860,	519,211	278,331	122,228	919,770	56.45	30.24	13.27
1861,	409,229	195,278	127,037	731,544	55.94	26.69	17.37
1862,	470,315	186,660	130,687	787,662	59.71	23.69	16.60
1863,	577,638	212,005	157,961	947,604	**60.96**	22.37	16.67
1864,	684,018	241,853	210,125	1,135,996	60.21	21.29	18.50
1865,	479,558	262,342	189,682	931,582	51.46	28.16	20.38
1866,	749,367	332,580	268,396	1,350,343	55.49	24.63	19.88
1867,	798,638	344,341	318,647	1,461,626	54.64	23.56	21.80

PRODUCTION OF PIG-IRON—*Continued.*

YEARS.	NET TONS OF 2,000 POUNDS.				PERCENTAGE OF TOTAL MAKE.		
	Anthracite.	Charcoal.	Bituminous.	Total.	Anthracite.	Charcoal.	Bituminous.
1868, ...	893,000	370,000	340,000	1,603,000	55.71	23.08	21.21
1869, ...	971,150	392,150	553,341	1,916,641	50.67	20.46	28.87
1870, ...	930,000	365,000	570,000	1,860,000	50.00	19.62	30.38
1871, ...	956,608	385,000	570,000	1,911,608	50.04	20.14	29.82
1872, ...	1,369,812	500,587	984,159	2,854,558	47.98	17.54	34.48
1873, ...	1,312,754	577,620	977,904	2,868,278	45.77	20.14	34.09
1874, ...	1,202,144	576,557	910,712	2,689,413	44.69	21.44	33.87
1875, ...	908,046	410,990	947,545	2,366,581	38.37	17.37	44.26
1876, ...	794,578	308,649	990,009	2,093,236	37.96	14.75	47.29
1877, ...	934,797	317,843	1,061,945	2,314,585	40.39	13.73	45.88
1878, ...	1,092,870	293,399	1,191,092	2,577,361	42.40	11.38	46.22
1879, ...	1,273,024	358,873	1,438,978	3,070,875	41.45	11.68	46.87
1880, ...	1,807,651	537,558	1,950,205	4,295,414	42.09	12.51	45.40
1881, ...	1,734,462	638,838	2,268,264	4,641,564	37.37	13.76	48.87
1882, ...	**2,042,138**	**697,906**	2,438,078	**5,178,122**	39.41	13.48	47.08
1883, ...	1,885,596	571,726	**2,689,650**	5,146,972	36.64	11.11	52.25
1884, ...	1,586,453	458,418	2,544,742	4,589,613	34.57	9.99	44.56
1885, ...	1,454,390	399,844	2,675,635	4,529,869	32.11	8.83	**59.06**

In all the tables full-face figures indicate the maximum product in any one year.

This statement shows that the proportion which the output of charcoal pig-iron bears to the total pig-iron production was less in 1885 than ever before, having decreased from nearly one half of the total. in 1854, to about one twelfth, in 1885, yet the quantity of charcoal pig-iron made in 1885 was 11 per cent. greater than in 1854, and in no year, prior to 1872, was more charcoal pig-iron made than was produced last year. The percentage of total make, by the various fuels, demonstrates the enlargement of the mineral fuel industry, rather than a continuous decline of the charcoal iron interests. In the years 1876, 1877, 1878, and 1879, the output of charcoal iron was less than in 1885, but the percentages of the total make were much greater than last year.

We start the year 1886 with less than 29 per cent. of the charcoal furnaces in blast, and with an accumulation of stock on hand equivalent to 58 per cent. of the product in 1885. Many of the furnaces out of blast made no preparations for cutting wood for the coming season, and it is, therefore, doubtful if the amount of charcoal pig-iron produced in 1886 will be much in excess of that of 1885, unless some very decided improvement in price would encourage unusual activity; for an output equal to that of 1885 would, together with the stock now on hand, be sufficient to meet a consumption of charcoal pig-iron nearly as great as in 1881, and approximate the make of charcoal pig-iron in 1882, which was the year of maximum production, when 697,906 net tons were made.

By analyzing the above tables, it will be noticed that the amount of charcoal iron made in 1885 is not only less than the product of the year previous, but that the stock in makers hand's shows an increase of 10,190 tons, while the total stock was reduced 176,404 net tons.

To present the relative consumption of charcoal iron in the past four years, we have added to the stock on hand at the beginning of each year the amount produced during the year, and deducted the stock on hand at the close of the year, which gives the following figures:

Approximate consumption of charcoal iron in the year 1881, 650.958 net tons.

Approximate consumption of charcoal iron in the year 1882, 616,726 net tons, indicating a decrease in one year of 5.9 per cent.

Approximate consumption of charcoal iron in the year 1883, 552,972 net tons, indicating a decrease in one year of 9.7 per cent.

Approximate consumption of charcoal iron in the year 1884, 420,234 net tons, indicating a decrease in one year of 24.0 per cent.

Approximate consumption of charcoal iron in the year 1885, 389,654 net tons, indicating a decrease in one year of 7.3 per cent.

The approximate consumption of charcoal pig-iron in 1885 was but 60 per cent. of what it was in 1881.

Following the same method of estimation, the approximate consumption of mineral fuel iron was 3.63 per cent. more in 1885 than in 1881.

By a close scrutiny of the tables, and comparing them with this statement, we notice that during 1881 the consumption exceeded the production by 12,120 net tons, but in 1882 about 81.189 net tons of charcoal iron were added to stock on hand, and this has been augmented in the years 1883, 1884, and 1885.

The following table shows the production of charcoal iron by States since 1872, and also the total output of iron made with various fuels:

Production of Charcoal Pig-Iron from 1872 to 1885, by States.

STATES.	TONS OF 2,000 POUNDS.						
	1872.	1873.	1874.	1875.	1876.	1877.	1878.
Maine,	....	780	1,661	2,046	3,002	1,960	1 190
Vermont,	2,000	3,100	3,450	2,400	550	210	585
Massachusetts,	12,820	15 704	17,777	10,115	5,040	2,904	1 426
Connecticut,	22 700	26,977	14 518	10,880	10,160	14,443	15 880
New York,	19,812	29,329	28 293	11,496	8,085	16 563	15,762
Pennsylvania,	45 033	45,854	40,978	34 401	23,699	9 636	29 360
Maryland,	29,044	30,315	25 003	1.150	13 863	17 394	17,782
Virginia,	21,445	22,475	23,451	15,396	7,350	6,193	8,333
North Carolina,	1,073	1,432	1 340	900	400	325	.
Georgia,	2 945	7,501	4.270	3,523	500	4 029	2 503
Alabama,	12,512	22,283	32.863	25,108	23 317	24,841	23,993
Texas,	619	280	1,012	. .	426	525	.
West Virginia,	950	1,950	3,400	1,100	300	1 250	406
Kentucky,	39,699	42,219	36,444	22,297	17.214	17,004	16 928
Tennessee,	34,094	34,532	37,227	18 011	10.068	11,208	11,227
Ohio,	95,622	100,498	92,835	61,976	48,931	42,117	33,513
Indiana,	.	. .	2,100	1,700	1,678	1 260	
Michigan,	96,840	113,975	128 969	101,905	82,447	75,216	70,853
Wisconsin,	27,790	35,890	28,973	26,483	26,261	22,205	27,487
Missouri,	45,589	39 536	49,093	39,786	24,113	28,560	16,861
Oregon,	.	. .	2,500	1 000	1,750	. .	1,310
Minnesota,	......	......	...	. .	...	...	...
Utah,	.....	......	200	150	65	....	....
California,	....	.....	....	....	....	.....	....
Washington Territory,	. .	....	.. ..	.	. .	......	...
Total,	500,587	577,620	576,557	410,990	308,649	317,843	293,399

TOTAL IRON PRODUCTION ACCORDING TO FUEL USED.

	1872.	1873.	1874.	1875.	1876.	1877.	1878.
Anthracite coal,	1,369,812	1,312,754	1,202,144	908 046	794,578	934,797	1,092,870
Charcoal,	500,587	577,620	576 557	410,990	308,649	317,843	293 399
Bituminous coal and coke,	984,159	977,904	910,712	947,545	990,009	1,061,945	1,191,092
Total,	**2,854 558**	**2,868,278**	**2,689,413**	**2,266,581**	**2,093,236**	**2,314,585**	**2,577,361**

Production of Charcoal Pig-Iron from 1879 to 1885, by States.—*Continued.*

STATES.	TONS OF 2 000 POUNDS.						
	1879.	1880.	1881.	1882.	1883.	1884.	1885.
Maine,	1,240	3,578	4,400	4,100	4,000	. . .	440
Vermont,	625	1.800	2 796	1,210	. . .		
Massachusetts,	5,010	9,862	12,360	10,335	10,769	4,902	869
Connecticut,	16,759	22,583	28,483	24,342	19,976	14,174	17,500
New York,	18,129	27,844	30,467	30,710	25,680	23,488	14,682
Pennsylvania,	35,895	43,374	51,968	49,975	38,315	23,155	12,148
Maryland,	19,734	33,050	27,626	28,277	23 807	15,123	10,432
Virginia,	7,703	14,043	19,038	26,133	16 879	14,829	12,648
North Carolina,	. .	.	800	1,150	. .	435	1,790
Georgia,	4,133	7,277	13,404	15,565	13,054	9,615	5,797
Alabama,	31,901	37,737	44,221	55,541	57,385	59,448	77,578
Texas,	400	2,500	3 000	1,321	2,981	5,140	1,843
West Virginia,	200	3,245	1,200	. . .	. . .	.	
Kentucky,	12,736	21,174	16,778	17,165	13 981	7,882	4,707
Tennessee,	7 567	16 675	19,046	37,611	35 290	18,806	31,173
Ohio,	43,445	69,190	66,169	58,654	40,528	24,880	18 018
Indiana,		2,000		. .	. .		
Michigan,	101,539	154,424	187,043	210,195	173,185	172,834	143,121
Wisconsin,	31,430	42,913	47,702	55,369	39,349	25,812	19,629
Missouri,	17,837	15,769	43 241	54,327	34,112	31,558	21,785
Oregon,	2,500	5,000	6,100	6,750	7,000	3 640	3,832
Minnesota,	. . . .	3,520	7,442	8,126	8,000	. . .	
Utah,	. . . . .	. . .		57	. . . .	. .	
California,	. . . .	. . . . .	4,414	987	5,327	2 157	
Washington Territory,	. .	. .	1,200	. .	2,317	540	1,857
Total,	358,873	537,558	638,838	697,906	571,726	458,418	399,844

TOTAL IRON PRODUCTION ACCORDING TO FUEL USED.

	1879.	1880.	1881.	1882.	1883.	1884.	1885.
Anthracite coal,	1,273,024	1,807,651	1,734,462	2,042,138	1,885,596	1,586,453	1,454,390
Charcoal,	358,873	537,558	638,838	697,906	571,726	458 418	399,844
Bituminous coal and coke,	1,438,978	1,950,205	2,268,264	2,438,078	2,689,650	2,544,742	2,675,635
Total,	3,070,875	4,296,414	4,641,564	5,178,122	5,146,972	4,589,613	4,529,869

The Tariff.

The first official action taken by the United States Association of Charcoal Iron Workers, in relation to duties upon the products of charcoal iron works, was in shape of a protest presented before the Committee on Ways and Means of the House of Representatives at Washington, March 6, 1886.

In the organization of the Association, in 1879, the duty of seeing that charcoal iron was protected was discussed as one of the reasons for uniting in an association. In 1883, a number of members, acting individually, secured the adoption of special provisions for protecting American charcoal iron in the revised tariff, but these provisions were nullified by the interpretation which the Treasury Department placed upon them.

When the announcement was made that, in considering the bill now pending to reduce duties, the Ways and Means Committee desired to hear from the industries affected, President Fuller called a meeting of the Executive Committee, but before proper action could be taken, he was notified that a hearing by the committee would be granted in three days. A delegation was hurriedly brought to Washington, and a form of protest agreed upon; ex-President George B. Weistling was requested to present the protest as chairman of the delegation, and he did credit to himself and the organization he represented by his effort.

As will be seen from the protest, which we give below, a plain statement of facts was presented. This was ably supplemented by frank, decisive answers to inquiries from members of the Committee on Ways and Means, and embellished at the close by witty *repartee*, which, while it amused the Congressmen and the audience, also assured all that the speaker was in earnest.

The charcoal iron interests were heard on the same day that pig-iron and iron ore were presented to the committee, and we have no reason to feel that, although sandwiched in between other interests, charcoal iron was not strongly impressed upon all who attended the hearing. It showed that the industry was active, and that its representatives were prepared to protest against crippling that branch of the iron trade, which, although overshadowed by the largely augmented output of mineral fuel blast-furnaces, had not been behind in progressive spirit.

Protest of the United States Association of Charcoal Iron Workers against House Bill No. 5576.

Presented to the Committee on Ways and Means, Washington, D. C., March 6, 1886.

By Col. GEORGE B. WEISTLING, *Chairman Special Committee.*

The United States Association of Charcoal Iron Workers, an organization extending throughout most of the States and Territories, and embracing in its membership a large majority of the producers and users of charcoal iron, respectfully present the following:

1. The charcoal iron industry is more widely distributed than any other branch of the iron business, being in existence in twenty-three States and two Territories, the most prominent producers being in order: Michigan, Alabama, New York, Tennessee, Pennsylvania, Missouri, Wisconsin, Ohio, Connecticut, Virginia, and Maryland.

2. More labor is directly employed per ton of product in the charcoal iron industry than in any other single branch, and this labor is of a diversified kind, being engaged in mining ores, chopping wood, making charcoal, reducing the ores in furnaces or forges, working iron into blooms, slabs, billets, bars, rods, castings, etc., in forges, mills, foundries, and shops.

3. The reductions made in customs-duties by the tariff revision of 1883 have materially injured the charcoal iron industry, and, in some specialties, it has been so crippled that works are idle, and must remain so until relief is given by higher duties or until American labor is reduced to the basis of that in foreign countries.

4. While naturally sympathizing with any depression of the iron business, a special effect of reductions in duties upon the charcoal iron industry is evident from the percentage of decrease in charcoal pig-iron production as compared with the total make of pig-iron.

From 1878 to 1883, the percentage of increase for the total pig-iron production was 101 per cent., and during the same period, the production of charcoal pig-iron increased 138 per cent., indicating a determination to keep abreast of the times and utilize all economic methods.

In 1883, (the year of tariff revision,) the total pig-iron production was increased 6.6 per cent., but the output of charcoal pig-iron was less than in 1882 by 18 per cent.

In 1884, the charcoal pig-iron production decreased 19.8 per cent., and in 1885, 12.8 per cent.

The decrease in the three years since the adoption of the present tariff is as follows:

Total pig-iron, 12.5 per cent.

Charcoal pig-iron, 42.7 per cent.

Such a marked decline cannot be accounted for by general business depression; but allowing liberally for this, as well as for any possible loss in specialties of domestic manufacture affecting the production of charcoal pig-iron, we assert that the tariff of 1883 has caused a decline of output in the manufacture of charcoal iron much greater than in pig-iron made with mineral fuel.

5. That the industry has been well sustained by those engaged in it, and that the decreased production is not due to timidity, is evident from the increase of stocks.

On January 1, 1883, the stock of charcoal pig-iron represented 27.5 per cent. of the total pig-iron in makers' hands, and this proportion has steadily increased until. on January 1, 1886, it represented 55.8 per cent. of the total stock, and more than half of the product of charcoal pig-iron in 1885.

6. The wide distribution of the charcoal pig-iron industry commands attention from Congress, and the possibility of foreign iron being brought close to most of the furnaces by vessels entering the ports of the Atlantic, Pacific, or gulf, or through the Mississippi jetties. the Welland canal, and our great river and lake system, (thus practically opening any market in the country by reduction of tariff,) demonstrates that protection is in no sense local, but strictly national.

7. The steadily increased production of charcoal blooms was checked by the interpretation of the tariff of 1883, which admitted foreign wire rods, steel blooms, etc., at low duties, and since that time the decline has been so rapid that less than one half the quantity of charcoal blooms was made in 1885 than was produced in 1882.

8. Notwithstanding the severe injury done by the tariff of 1883 to the charcoal iron industry, the manufacturers have borne the burden rather than disturb business by appealing for relief to Congress and encouraging another tariff discussion. They have, in many cases, continued their business at a loss, giving employment to those depending upon them, and hoping that Congress would at least prevent any further agitation of the subject.

We respectfully and firmly protest against any further reduction of duties. On the contrary, we ask that duties equivalent to those in existence prior to the year 1883 be reëstablished, and we especially urge that all duties be made specific.

We also urge your committee to report such duties as will encourage the manufacture from American iron of tin plates, of which over 200,000 tons are annually imported.

We make this protest, not solely as a protection to capital, but also as a duty to the many thousands of mechanics and laborers dependent upon the industries we represent. An examination of the facts will demonstrate the injury already done to our industries, and show that any further reduction of duties will be at the sacrifice of American labor.

(Signed,) J. C. FULLER,
President.

ATTEST: JOHN BIRKINBINE,
Secretary.

◆

MR. LITTLE, of Montreal, a lumberman well known for his enthusiastic interest in forestry, said that the lumbermen were to blame for most of the forest fires. It was their careless and wasteful methods of lumbering that made forest fires possible. He had not lost more than 1 per cent. by fire in all his lumbering operations. It was the limbs of the trees, left by the lumbermen to wither and dry where the trees fell, instead of being removed, which afforded the ready fuel for any chance spark that might fall from the smoker's pipe or the unextinguished camp-fire.

◆

DURING the fiscal year 1885, there were imported into the United States from Sweden 1,174 gross tons pig-iron, 21,082 gross tons wire rods, and 29,279 gross tons bar-iron.

British Iron and Steel Exports in 1885.

The aggregate shipments of iron and steel from Great Britain in December amounted to 218,054 gross tons, against 230,438 tons in November. The total shipments for the year 1885 amounted to 3,128,401 tons, against 3,496,352 tons in 1884. The following is a comparative table for each month of the last three years:

MONTHS.	TONS.		
	1883.	1884.	1885.
January,	289,802	243,592	202,956
February,	255,844	241,221	209,121
March,	333,189	286,548	260,427
April,	338,459	305,949	264,400
May,	374,579	366,992	275,639
June,	380,506	326,869	298,519
July,	361,414	336,033	271,691
August,	365,500	273,437	281,112
September,	367,361	309,704	319,671
October,	356,487	317,651	296,373
November,	342,051	259,494	230,438
December,	279,081	228,862	218,054
Total,	4,044,273	3,496,352	3,128,401

The following is a comparative table of the shipments to the United States for November and December, and for the 12 months of 1884 and 1885:

ARTICLES.	GROSS TONS.			
	Nov., 1885.	Dec., 1885.	Twelve months. 1884.	Twelve months. 1885.
Pig-iron,	10,804	13,870	157,010	113,502
Old iron,	1,945	3,887	25,531	14,246
Steel unwrought,	2,154	2,078	14,602	14,648
Tin-plates,	18,417	16,551	211,925	223,869
Hoops and sheets,	1,410	996	21,370	21,857
Bar, angle, etc.,	275	205	4,275	2,215
Rails,	37	308	17,829	5,777
Cast and wrought,	259	179	2,523	1,499
Total,	35,301	38,074	455,065	397,613

Charcoal Manufacture in Servia.

It has been our constant aim to present in the JOURNAL information concerning the details of wood cutting, charcoal production, and iron manufacture in various portions of our own country, as well as the methods used in other countries, and it is with much gratification that we submit to our readers the following information concerning the getting of wood and the manufacture of charcoal in Servia.

For the data here presented, we are indebted to a member of the Association, Mr. F. W. Barnes, of Vienna, Austria, engineer and works manager to Gustav Chaudoir & Co., Simmering, Vienna, who is now on a visit to the United States, and who will be remembered by some of our readers as furnishing information concerning a charcoal blast furnace constructed at Majdenpek, Servia.*

This furnace, Mr. Barnes states, has not been blown in, chiefly on account of the war between Servia and Bulgaria, which has unsettled all business enterprise.

The copper-smelting works use a considerable quantity of charcoal, and the methods followed in its manufacture, as well as in cutting and handling the wood, will be novel to most of our readers, although some of the special features are common in other parts of Europe.

Majdenpek is situated in the mountain district, of the north-eastern section, of Servia, (in the Negotin Kreise,) near the boundary dividing it from Bulgaria. Its climate would appear similar to that of the Adirondack region of New York, or of the upper peninsula of Michigan, the winter snows lying on the ground generally from the last of November to the middle of March, and it is during this season that the wood-supply is prepared, it being the practice of the company to cut the wood in one winter, allow it to stand in ranks through the next winter to season, and make it into charcoal during the season following; that is, except when short of charcoal, the practice has been to use no wood which has not been cut over one year, the results obtained being considered as amply repaying, in augmented yield, the interest and risk.

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*Vide JOURNAL, Vol. IV, p. 204.

THE WOOD-SUPPLY.

The steep mountain sides and the valleys abound in white beech and small lots of birch, with some oaks and lindens, the former predominating and forming the bulk of the virgin forests. During the summer, some of the regular employees expressly skilled are sent out to select and fell the best oak trees, and sometimes lindens, for producing merchantable lumber. For felling each tree and roughly removing the branches, these men are paid one piastre (four cents.)

With the advent of the winter snow, peasants come from their homes, sometimes forty miles distant, to cut the wood, living in huts in the forest during the winter. These choppers use axes, and cut the area designated clean, except a stipulated reserve of seed trees, which are left mostly on crests of the range. They generally work in parties, and, commencing at the foot of a hill, chop all trees nearly through, but let them stand until a desired point is reached further up the hillside, when the upper rows of trees are thrown, they carrying with them those below, until the whole tract has been felled. The limbs are then removed, and the trees cut into lengths of two metres, with no allowance for either point, making the sticks over seven feet long from point to point, or if measured from point to scarf, as in this country, probably 6.8 feet.

This wood is piled in ranks four metres long by one and a quarter metres high, called *Klaftas*. This gross measurement, 13.12 feet × 4 feet × 6.8 feet = 356.864 cubic feet, or 2.788 cords. The wood will probably average 20 inches in diameter, and all over 10 inches diameter must be split. The piling is not done with special care, as the extra height of one fourth metre is to allow for bad piling. The net Klafta measurement, is eight cubic metres=282.53 cubic feet, or 2.21 cords (which will be the comparison adopted in this sketch,) and no ranks of less than one half *Klafta* (1.115 cords) are permitted even on the roughest ground, and single ranks often contain several *Klaftas*. In settling for the wood, however, only full *Klaftas* are paid for, and this settlement is invariably made on the Thursday before Easter, when all is paid in full. Money is very seldom expected or paid, except at this time, when wood-cutting ceases, nor are any store goods given. The price for chopping is thirteen piastres (52 cents) per *Klafta*, or say

23.5 cents per cord. Most of these peasants own their own homesteads, in which they are protected by rigid laws, have a yoke of oxen, and raise corn and swine during the the warmer weather, on which they subsist during the winter months. They wear scanty clothing for such a rigorous climate, can neither read or write, and keep their accounts by notches cut upon sticks.

Stumps are not permitted over one metre (3.28 feet) high, except when deep snows prevent cutting the trees at that height.

Where wood lies in the valley through which the two-feet gauge railroad of the company passes, or in transverse valleys convenient to the railroad. it is loaded on open cars, each holding about three quarters of a *Klafta*, (1.66 cords,) and carried to the works, to be used in roasting ore, in generating steam, or for producing charcoal in kilns.

A *Klafta* of beech wood weighs from 3¾ to 4 gross tons, but a *Klafta* of seasoned wood (cut at least one year) weighs 3 gross tons. This is equivalent to a weight per cord of say 3,500 to 4,000 pounds for green wood and 3,000 pounds for dry wood.

Much of the cut wood is sent down the steep hillsides by chutes made of logs, but the favorite method is *zur-rucking*, by which the sticks are thrown down hill sometimes over 1,000 feet, starting the sticks revolving end over end on their points. They attain a high velocity, and an expert handler can deliver them in this way at long distances. For *zur-rucking*. when not over two starts are necessary, the pay is 5 piastres per Klafta, or 9 cents per cord.

CHARCOAL PRODUCTION.

The general practice is to carbonize the wood in meilers in the felled forests, but some of the wood which is convenient to the company's narrow-gauge railroad is transported to the works and there carbonized in three rectangular kilns, each having a capacity of 28 *Klaftas*, or 62 cords.

The operation of these kilns has not been as satisfactory as desired. the reason assigned being that the walls are constructed of stone two feet in thickness, which prevent hermetical sealing. Each kiln has two outside fire-places, with flues leading into the structure.

The meiler coal is produced by two methods. For the localities most convenient to the works or the railroad, the company gives employment to about forty Roumanian charcoal burners, each of whom owns a wagon and a pair of oxen. These men are paid four piastres per *mass* for charcoal delivered at the works or on railway cars. As a *mass* is equivalent to about eight and a half bushels, and four piastres are equal in value to 16 cents, the price paid is practically two cents per bushel—one cent for coaling and one cent for hauling. The colliers prepare and drain the hearths, haul in the wood, provide their own leaves, dust, etc., and, in fact, do everything necessary to take the wood as ranked in *Klaftas* and deliver the charcoal on cars or at works.

The meilers are made of standing wood, two tiers high, with top rounded out with lap wood, and contain from fourteen to twenty *Klaftas* each; that is, from 31 to 44 cords.

The yield obtained varies from five and a half to nine *masses* per *Klafta*, the average being seven and a half *masses*. On the basis of eight and one half bushels per *mass*, this average is equivalent to 28.9 bushels per cord. The best yield of charcoal is seventeen per cent. of the weight of the dry wood placed in the meiler, but the average work is below this amount.

The second method is adopted for carbonizing wood in inaccessible localities or where no rough wagon roads exist or can be made conveniently. As soon as the snows disappear, about two hundred and fifty Bulgarian charcoal burners are employed, each man owning two ponies, which he brings with him. The company allow these men free pasture for their stock on any uninclosed lands, but they must, like the other colliers, take all risks of wind or storm, and do everything necessary to take the wood from ranks and deliver the charcoal at the works. The wood is carbonized in small meilers, one tier in height, containing about seven *Klaftas*, (15.5 cords,) and the charcoal is transported in sacks, two of which are slung over a pony's back by a rough saddle. Each sack holds 35 kilogrammes, or 4¼ bushels, so that a pony brings at a load one *mass* of charcoal. The colliers take turns in leading the ponies, one man being able to lead over rough trails sixty to eighty animals. Two to three trips are made daily, depending upon the distance of the coal job.

Upon arrival at the works, the sacks are emptied into a square wooden box with handles, the sides and bottom being made of slats, with openings of two inches between them. As the charcoal is poured in, the box is shaken, and all coal which falls through the openings is not paid for. When full, this measure is one *mass.* These colliers are paid from five to five and a half piastres per *mass* (2.35 to 2.6 cents per bushel) for coal so delivered.

Estimating no value for standing timber, but calculating on a yield of 7½ *masses* per *Klafta*, (28.9 bushels per cord, allowing 8½ bushels per *mass*,) we find the cost of producing charcoal to be as follows:

	First method.	*Second method.*
Cost of cutting wood per bushel of charcal at 13 piastres per *Klafta*,	**0.8 cents.**	**0.8 cents.**
Cost of carbonizing and delivering charcoal per bushel,	**2.0 do.**	**2.6 do.**
A total of,	**2.8 cents.**	**3.4 cents.**

Mr. Barnes reports that the average cost of charcoal delivered at the works, including management and incidentals, but placing no value on the wood, was twenty francs per metric ton, equivalent to 3.26 cents per bushel of 18 pounds, (the coal being about that weight,) or 3.63 cents per bushel of 20 pounds.

The charcoal burners are paid partially on account during the working season, but they, like the wood-choppers, have a regular settling day, when all is paid in full. This is All Saints' Day, which occurs about November 1.

ESTIMATES have been made showing the cost of fences in the United States to be $1,700,000,000, and the annual cost for maintenance at $198,000,000, including interest at 6 per cent. upon the original cost. The farm fences in the State of Maine are estimated at 41,952,000 rods, or 131,000 miles in length. The first cost cannot be reckoned at less than $42,000,000. Upward of $8,000,000 are invested in farm fences in Connecticut. Total cost of fencing in New York State aggregates $228,874,611; Pennsylvania, $179,834,494; Ohio, $155,580,673; Indiana, $100,759,415; Illinois, $128,856,513.

Blast Furnace Balance Sheet.

The *Journal of the Iron and Steel Institute* publishes a translation of an interesting communication in the *Chemiker Zeitung*, by Baron H. von Jüptner, presenting what is appropriately called a blast furnace balance-sheet. There is so much of value in the translation that we offer it to our readers entire, as follows, regretting that the name, locality, and dimensions of the German furnace referred to are not given:

In the week during which the experiments lasted, there were charged 249.6 metric tons of ore, 6 tons of iron from cinder, 26.1 tons of limestone, and 106.5 tons of charcoal. The products were: Pig-iron, 114.6 tons; slag, 64.6 tons; flue-dust, (dry,) 3.3 tons; iron from cinder, 6 tons. The temperature of the blast was 350° C. (662° F.,) and its pressure, 60 millimetres ($2\frac{3}{8}$ inches) of water. The tuyeres were 55 millimetres ($12\frac{3}{16}$ inches) wide; the mean temperature of the waste gases was 127° C., (260° F.;) the moisture in the blast was, by weight, 0.87 per cent.; the mean temperature of the air was 17° C., (63°F.,) and the mean height of the barometer, 710 millimetres, (28.95 inches.)

The materials of the charge and the products obtained had the following composition:

	Ore.	Limestone.	Slag.	Flue-dust.	Charcoal.*
K_2O,	....	....	....	0.85	0.10
Na_2O,	....	....	....		0.06
CaO,	0.92	54.08	26.25	6.35	0.76
MgO,	4.72	0.60	16.07	3.39	0.17
FeO.	20.27	....	5.56	16.59	....
Fe_2O_3,	41.18	....	....	40.50	0.01
Al_2O_3,	2.11	0.16	7.07	2.95	....
Mn_3O_4,	2.80	....	3.89	2.98	....
CuO,	0.076	....	0.13	0.06	....
SiO_2,	12.85	0.44	39.99	13.75	0.47
SO_3,	0.288	0.03	1.04	0.30	0.03
P_2O_5,	0.288	0.03	.007	0.072	0.05
CO_2,	2.32	43.15	....	6.79	0.63
H_2O,	12.50	1.58	....	....	10.25
C,	....	....	....	4.75	86.25
N,	....	....	....	....	0.52
Disposable hydrogen,	....	....	....	....	1.01
Total,	100.262	100.07	100.007	99.382	100.34

* This is an unusually complete analysis of charcoal. It will be noted that it contains but 86.25 per cent. of carbon and carries 10.25 per cent. of water.—ED.

The pig-iron had the following composition:

Iron,	91.761	
Combined carbon,	0.892	
Graphite,	2.800	
Silicon,	1.800	1.8
Sulphur,	0.018	
Phosphorus,	0.042	
Manganese,	2.650	2.7
Copper,	0.032	29.095

The mean volumetric composition of the waste gases was:

CO^2,	8.5	19.73
CO,	28.1	39.56
O_2,	0.4	
CH_4,	0.8	
H_2,	7.1	
N_2,	55.1	
	100.	

For one ton of pig-iron produced, the following quantities of materials were charged into the furnace:

	Tons.	
Ore,	2.1618	2.15
Limestone,	0.2277	.23
Charcoal,	0.9378	.93
Iron from cinder,	0.0523	.05
Total,	3.3796	

For every ton of pig-iron produced, there were also obtained:

	Tons.
Iron from cinder,	0.0523
Slag,	0.5640
Flue-dust,	0.0285
Total,	0.6448

Consequently, for every ton of pig-ion produced, 1.7348 tons of the charge had escaped as gas.

For every 100 tons of pig-iron produced, the following quantities were charged into the furnace (tons):

K_2O,		0.097
Na_2O,		0.056
CaO,		15.034
MgO,		10.493
FeO,	44.18	43.765
Fe_2O_3,	58.77	88.929
Al_2O_3,		4.598
Mn_3O_4,	6.18	~~6.046~~
CuO,		0.124
SiO_2,		27.847

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SO_3,	0.656	
P_2O_3,	0.117	
CO_2,	15.471	15.5
H_2O,	36.925	37.14
C,	80.624	
N,	0.487	
Disposable hydrogen,	0.947	1.4
Total,	332.216	

As 5.23 tons of grain iron from the cinder were also charged, the total weight of the charge per 100 tons of pig-iron produced was 337.446 tons.

For every 100 tons of pig-iron produced, 56.372 tons of slag and 2.85 tons of flue-dust were produced, and the compositions of these latter were as follows:

	Slag, tons.	Flue-dust, tons.
K_2O,	....	0.024
Na_2O,	....	
CaO,	14.801	0.181
MgO,	9.061	0.112
FeO,	3.121	0.472
Fe_2O_3,	....	1.154
Al_2O_3,	3.986	0.084
Mn_3O_4,	2.193 (as MnO)	0.090
CuO,	0.063	0.002
SiO_2,	22.557	0.391
SO_2,	0.586 (partly as S.)	0.009
P_2O_5,	0.004	0.002
CO_2,	....	0.194
C,	......	0.125
Totals,	56.372	2.850

The pig-iron produced being 105.23 tons, the total amounts to 164.452 tons.

The calculation of the composition of the waste gases would show them to contain per 100 tons of pig-iron produced (tons):

K_2O.	Na_2O.	CaO.	MgO.	FeO.	Fe_2O_3.	Al_2O_3.	Mn_3O_4.
0.097	0.032	0.052	1.320	1.119	——	0.528	0.085

CuO.	SiO_2.	SO_3.	P_2O_5.	CO_2.	H_2O.	C.	N.
0.003	1.052	0.016	0.015	15.277	36.925	76.797	0.487

Disposable Hydrogen.	*Total.*
0.947	134.824

In 100 litres of the waste gases, there were 0.0287 grammes of cyanogen; for every 100 tons of pig-iron, there was, consequently, present 0.143 ton of potassium cyanide.

The derivation of the carbon, hydrogen, nitrogen, and oxygen in the waste gases, per 100 tons of pig-iron, was, in tons:

	From the charge.	m the decomposition of water.	From the blast.	Total.	By analysis.	Difference.
Carbon,	80.930	. . .	. . .	80 930	80.930	
Oxygen,	49 467	18.752	82.897	151.116	144.125	6.991
Hydrogen,	0.947	2.369	. .	3.316	3.316	
Nitrogen,	0.454	. . .	277.526	277.980	277.980	

The difference shown in the case of the oxygen is the total error from all the different causes, and is about the same as that given by Sir I. Lowthian Bell.

The total amount of heat introduced into the furnace, and produced there, was:

	Calories.	Per cent.
Introduced with the blast,	3,055,398.2	9.23
" " " charge,	87,127.3	0.26
Produced in the furnace,	29,940,211.0	90.51
Totals,	33,082,736.5	100.00

The heat consumed was as follows:

	Calories.	Per cent.	
For chemical processes in the blast furnaces,	16,521,893.5	49.94	56.0
For the evaporation of the moisture introduced with the charge,	2,545,978.8	7.69	— 6.8
In fusing the pig-iron and slag,	5,743,730.0	17.36	10.
Loss of heat in the flue-dust,	24,456.3	0.07	.02
Heat carried away by the waste gases,	1,799,230.3	5.43	[illegible]
Heat lost by conduction and radiation,	6,447,447.6	19.51	12.
	33,082,736.5	100.00	[illegible]

This is, to our notion, a model presentation of the operation of a charcoal blast furnace, and we invite particular attention to several features.

The charcoal is shown to contain 0.16 per cent. of potash and soda, 0.96 per cent. of lime and magnesia, 0[illegible]1 per cent. of sesquioxide of iron, 0.47 per cent. of silica, 0.012 per cent. sulphur, and 0.022 per cent. phosphorus, the carbon being but 86.25 per cent., and the moisture 10.25 per cent. We seldom realize how many of the elements enter into the composition of wood, either by the sap carried from the soil, or absorbed from the atmosphere by leaves, or how the proportions of the various compounds vary with the different soils upon which trees grow.

From the data given, the ore yielded 46.2 per cent., and the lime charged was 10.5 per cent. of the ore burden. The consumption of charcoal, per ton of 2,240 pounds, was 2,100 pounds, or 105 bushels of 20 pounds each, (the actual carbon consumed was 1,810 pounds,) which, considering the yield of the ore and low-blast temperature, is fairly good work.

For every ton of pig-iron made, there was charged into the furnace 828.1 pounds of water, and 623.84 pounds of silica; the slag made was equal to 1,262.69 pounds, and 63 pounds of flue-dust was produced. The calorific effect of heating the blast to 662° F. was but $\frac{1}{10}$ of that produced in the furnace, but 83 per cent. of this was absorbed in evaporating moisture from the charge, and double the amount of heat introduced by the blast was lost by conduction and radiation. Less heat was required to fuse the pig-iron and slag than was lost by radiation and conduction. Of the moisture charged into the furnace per ton of iron made, 604.8 pounds was in the ore, 8.06 was in the flux, and 215.3 was in the charcoal.

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ALTHOUGH the Russian charcoal-iron industry is so depressed that at the close of last year's fair at Nijni Novgorod upward of 70,000 tons of pig-iron remained unsold, it would be too much to say that Russia is deriving little benefit from her mineral treasures. If we might venture to hazard a prediction, we should say that in a few years' time the export of iron ore will be one of the most important branches of Russian trade in the Black Sea.—*Ex.*

Swedish Mineral Statistics.

We are indebted to Professor Richard Ackerman, of Stockholm, an honorary member of the Association, for a copy of the official mineral statistics of Sweden, for the year 1884, from which he has courteously translated for the JOURNAL the following tables:

PRODUCTION IN METRIC TONS.	1880.	1881.	1882.	1883.	1884.
Iron ore, ...	775,344	826,937	892,863	885,124	909,553
Pig-iron, ...	405,713	435,428	398,945	422,627	430,534
Iron in rods, bars, etc., .	219,234	247,707	259,462	255,853	264,944
Bessemer iron and steel, .	30,013	39,328	47,358	50,878	53,123
Martin iron and steel, . .	7,718	11,158	13,405	16,800	19,354
Other kinds of steel, . .	1,550	1,741	1,430	1,827	1,764
Plates, ...	11,909	13,134	15,805	17,439	17,534
Nails, ...	7,445	7,132	8,143	8,197	9,720
Number of furnaces in blast,	193	197	185	191	178
Average length of blast of each furnace—days, .	210	227	217	216	227
Average daily production of each furnace in metric tons, ...	9.99	9.75	9.93	10.25	10.67

EXPORTS FROM SWEDEN.

METRIC TONS.	1880.	1881.	1882.	1883.	1884.	1885.
Iron ore, ...	29,670	24,282	20,200	32,219	40,000	25,817
Pig-iron, ...	61,594	55,489	55,500	52,126	55,000	47,531
Blooms, ...	8,842	8,802	8,000	6,258	8,500	9,364
Iron in rods, bars, etc.	179,978	188,556	208,000	194,839	196,000	*177,395
Plates of all kinds, .	2,210	2,382	2,200	2,373	2,400	3,288
Nails,	1,258	1,052	900	827	1,800	2,190
Ingot iron and steel,	8,161	7,165	9,800	11,214	10,500	4,158

*Iron and steel in bars, rods, etc.

We find in the volume an official comparison of Swedish and French values, to which we have added American equivalents.

1 kubikfot, = 0.02617 metre cube, = .92426 cubic foot.
1 centner, (ctr.,) }
100 skalpund, (℔,) } = 42.50758 kilogrammes, = 93.7122 pounds.
1 krona = 100 öre, = 1.39 franc, = 26.8 cents.
A metric ton, = 1.102 net tons = .984 gross tons, = 2,204.63 pounds.

The average product per furnace for the year 1885 was 56.901 centner = 2,666.17 net tons.

In mining the 909,553 metric tons of iron ore produced in 1884, there were employed 5,165 laborers on steady work, 514 on occasional work, and 602 women and children. The blast furnaces gave employment to 4,133 laborers, and the forges required the services of 7,627 men.

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CHARCOAL HAMMERED IRON.—Mr. J. M. Allen, in a lecture on steam boilers, makes the following pertinent remarks about what is called C. H. No. 1 iron:

"A good, charcoal hammered iron, honestly made, is well suited for boiler shells, and should show a tensile strength under test of 50,000 pounds per inch section, and a ductility indicated by 20 per cent. reduction of area at a point of fracture under test. It is a lamentable fact, however, that very little of the iron stamped C. H. ever saw a bushel of wood charcoal, and, in the haste with which some of it is made, the bars in the pile do not uniformly weld: hence, we have laminated plates, which, when put into the boiler and subjected to heat, develop blisters and other defects. We had occasion, not long since, to make tests of some iron from a fractured plate which was stamped C. H. No. 1; it showed a tensile strength of 50.000 and 52,000 pounds, with less than 8 per cent. ductility. When bent, it broke with a short fracture, and hardly any fiber before reaching 90°.

When a boiler is made, it is next to impossible for any inspection to detect the quality of the iron. In the sharp competition for business, a great deal of poor iron gets into boilers. It is cheaper, and the boiler can be sold for less money; and with the improved machinery for flanging, drilling, punching, and riveting, the poor quality of the material cannot be detected. But when subjected to the conditions of use, the frequent repairs soon convince the purchaser that his cheap boiler is a very expensive one after all."

The above emphasizes our editorial comment on C. H. No. 1 iron in the JOURNAL, Vol. VI, page 386.

Charcoal and Coke as Blast Furnace Fuels Compared.

(*Continued.*)

In the JOURNAL, Vol. VI, p. 339 to 343, we gave the results of some interesting experiments of Heir Belani, showing the comparative values of coke and charcoal for use in the blast furnace. Several contributions upon the subject have since appeared. the most interesting of which was translated for the *Iron Age*. It is the work of Dr. Wilhelm Thœrner, of Osnabrueck, who has gone at the problem in an experimental way, following up, by improved methods, the course pursued by Bell in England, and by Fulton in this country. In this instance, he took large samples of a series of cokes and charcoals, obtaining the following results:

	Ash, per cent.	DENSITY.		CELLSPACE IN 100 GRAMS.	
		Apparent.	Actual.	Cell space, c. cm.	Volume of fuel, c. cm.
1. Gas coke, Pluto,	3.8	1.825	0.858	61.6	54.8
2. Gas coke, Fr. der Gr.,	7.5	1.811	0.808	60.0	55.2
3. Pressed coke, Cöln Müsen,	7.7	1.852	0.984	47.6	54.0
4. Pressed coke, Cöln Müsen,	6.9	1.786	0.969	47.2	56.0
5. Coppée coke, Cöln Müsen,	7.99	1.880	0.926	54.8	53.2
6. Carlsglueck,	7.8	1.825	0.909	55.2	54.8
7. Maassener Tiefbau,	7.3	1.852	0.890	58.4	54.0
8. Westhausen,	10.6	1.852	0.919	54.8	54.0
9. Neu Iserlohn,	8.8	1.852	0.874	60.4	54.0
10. Dannenbaum,	8.45	1.894	0.890	59.6	52.8
11. Germaniahuette,	7.6	1.909	0.903	58.4	52.4
12. Heinrichshuette,	7.6	1.887	0.980	49.0	53.0
13. Meiler coke,	2.9	1.448	1.046	28.4	67.2
14. Charcoal, fir,	2.9	1.626	0.382	200.4	61.6
15. Charcoal, oak,	2.45	1.347	0.587	96.2	74.2
16. Charcoal, beech,	2.10	1.481	0.594	100.8	67.6
17. Charcoal, birch,	1.65	1.351	0.484	132.5	74.0
18. Piesburg anthracite,	9.3	1.666	1.572	3.6	60.0
19. Borgloh coal,	8.3	1.323	1.300	1.4	75.6

These figures show that there is considerable difference between the cell space in various charcoals and coke. The actual density—

that is, the density of the carbon itself—of course fluctuates only within narrow limits. Dr. Thœrner has studied the different fuels under the microscope, and in the original illustrates a number of slides. They prove clearly that with charcoal the structure of the wood is not at all impaired, while in the case of coke the substance of the cell walls is melted together to a dense vitreous mass.

Dr. Thœrner has also undertaken to determine the crushing strength of the various fuels, and, after reaching the conclusion that direct testing of cubes and cylinders does not yield reliable results, elaborated a method of his own. It consists roughly of crushing the fuel and screening to obtain a uniform size and then submitting it to pressure to observe the reduction in volume. Thus he obtained the following comparative results:

	Loss of volume under pressure. Per cent.
1. Gas coke, Pluto,	54.7
2. Gas coke, Fried. d. Gr.,	51.5
3. Pressed coke, Cöln Müsen,	47.6
4. Pressed coke, Cöln Müsen,	51.9
5. Coppée coke, Cöln Müsen,	48.6
6. Carlsglueck,	47.5
7. Maassener Tiefbau,	50.9
8. Westhausen,	48.5
9. Neu Iserlohn,	52.4
10. Dannenbaum,	51.9
11. Germaniahuette,	53.4
12. Heinrichshuette,	46.7
13. Meiler coke,	43.1
14. Charcoal coke, fir,	72.7
15. Charcoal coke, oak,	58.7
16. Charcoal coke, beech,	57.8
17. Charcoal coke, birch,	60.0

These figures indicate that porosity, as a general thing, has some influence upon the bearing capacity of the coke or charcoal. Thus, the more porous gas coke may be pressed together, while the compressed coke made by the Luermann process cannot be compressed as much, and is, therefore, better able to carry a burden. Similarly, the slightly porous meiler coke can only be compressed a little. As was to be expected, fir charcoal shows the least strength, followed by birch charcoal, then comes the denser oak charcoal, and not beech charcoal, as might be expected from its porosity. This variation shows that the carbonaceous substance of the more porous beech coal is in itself stronger than the denser oak charcoal.

The next series of experiments was made by Dr. Thœrner, to ascertain the action of carbonic acid and blast upon coke and charcoal. He made the observation that samples of both, dried at 140° to 150° Celsius, when heated to a higher temperature, though below that of the action of furnace gases, loses in weight to a greater or less degree, through the escape of hydrocarbons confined in the cell spaces. He exposed samples brought to a white heat for 30 minutes to a current of hydrogen, so that any oxidizing action was entirely out of the question. The following were the losses in percentages of original weight:

	Per cent.
2. Gas coke, Friedr. d. Grosse,	**0.25**
3. Pressed coke, Cœln-Muesen,	**1.40**
4. Pressed coke, Cœln-Muesen,	**1.15**
5. Coppée coke, Cœln-Muesen,	**1.13**
6. Carlsglueck,	**1.55**
7. Maassen Tiefbau,	**1.70**
8. Westhausen,	**1.70**
10. Dannenbaum,	**0.75**
13. Meiler coke,	**29.70**
14. Charcoal, fir,	**17.90**
15. Charcoal, oak,	**13.20**
16. Charcoal, beech,	**11.80**
17. Charcoal, birch,	**13.20**

This loss, which, it will be observed, is heavy in case of meiler coke and of charcoal, cannot be attributed to the escape of water. It is due to incomplete carbonization, which is proven by the fact that the gas escaping during the experiments showed only traces of carbonic acid and carbonic oxide, and that the presence of large quantities of hydrocarbons was detected in them. Dr. Thœrner then submitted samples of the fuels to the action of a current of carbonic acid for the period of half an hour, allowing about 800 to 1000 c. cm. of gas to pass over it. The following were the losses in weight due to a reduction of the carbonic acid to carbonic oxide by carbon:

COKES.	PER CENT.				
	½ hour.	1 hour.	1½ hours.	2 hours.	2½ hours.
1. Gas coke, Pluto,	10.6	16.8	20.9	25.0	27.2
2. Gas coke, Fr. d. gr.,	11.8	21.4	28.5	34.5	38.6
3. Pressed coke,	13.6	22.7	28.8	33.9	38.0
4. Pressed coke,	8.4	14.8	20.0	24.0	27.2
5. Coppée coke,	8.7	12.7	17.8	23.0	27.5
6. Carlsglueck,	8.3	15.0	20.9	25.5	29.3
7. Maassener T.,	8.0	14.4	20.2	25.8	29.3
8. Westhausen,	9.5	17.4	21.8	24.5	26.2
9. Neu Iserlohn,	12.2	17.8	23.1	28.9	34.0
10. Dannenbaum,	6.8	12.0	16.3	19.9	22.6
11. Germaniahuette,	8.9	17.6	23.5	28.4	32.0
12. Henrichshuette,	6.9	13.2	19.3	22.1	24.3
13. Meiler coke,	45.6	70.3	91.3	97.0	

Charcoals.	*15 minutes.*	*30 minutes.*
Fir,	61.1%	97.8%
Oak,	48.8%	92.0%
Beech,	60.4%	98.0%
Birch,	68.0%	98.4%

These figures show how much more quickly the carbon of charcoals is attacked by carbonic acid than that of cokes, meiler coke occupying an intermediate position.

Finally, Dr. Thœrner examined the effect of a current of air on the heated fuels, obtaining the following results after an exposure of 10 minutes:

	Loss by Action of Air. Per Cent.
1. Gas coke, Pluto,	46.8
2. Gas coke, Fried. d. Gr.,	45.0
3. Pressed coke, Cœln-Muesen,	51.0
4. Pressed coke, Cœln-Muesen,	48.9
5. Coppée coke,	50.1
6. Carlsglueck,	54.4
7. Maassener Tiefbau,	51.5
8. Westhausen,	52.9
9. Neu Iserlohn,	46.8
10. Dannenbaum,	57.1
11. Germaniahuette,	52.1
12. Henrichshutte,	52.5
13. Meiler coke,	87.7
14. Charcoal, fir,	100.0
15. Charcoal, oak,	78.6

16. Charcoal, beech,	**80.3**
17. Charcoal, birch,	**100.0**
18. Bergloh coal,	**74.4**

It is obvious that the affinity for oxygen on incandescent coke, meiler coke, and charcoal varies within wide limits, and that the loss is considerably greater than that brought about by the action of carbonic acid.

Dr. Thœrner holds that the cells of charcoal have walls easily penetrated by gases, and that their substance is very readily oxidized, while coke cell walls consist of a dense vitreous mass not easily penetrated by gases, and oxidized with difficulty. An approach to the efficiency of charcoal as a blast-furnace fuel can only be obtained by making the coke more porous, and yet retain its resistance to crushing effects, or to bring about a change in the physical characteristics of coke substance, so as to produce a modification more easily oxidized. Dr. Thœrner does not seem to be very sanguine as to the possibilities of attaining these ends.

THE following is a statement of the amount of ore shipped from Bilboa, Spain, from January 1 to December 31, 1885:

England.

	Tons.	*Tons.*
To Wales,	999,992	
" Cleveland district, England,	630,767	
" Lancashire, England,	10,856	
" Scotland,	404,773	
" other parts of England,	4,131	
Total for Great Britain,		2.050,519
To France,	492,144	
" Belgium,	171,771	
" Holland, (for Germany,)	572,520	
" America,	6,387	
Total,		1.242,822
Total exported,		3,293,341
Do. last year,		3,148,597
Increase,		144,744

Constitution of Car-Wheel Irons.

At the Pittsburgh meeting of the American Institute of Mining Engineers, the following very instructive data concerning the chemical composition of car-wheel irons were presented in a "Note on the Constitution of Cast-irons," by C. B. Dudley and F. N. Pease, chemists of the Pennsylvania railroad:

Those who have worked on the chemistry of pig-irons, of which the physical properties were known, cannot fail to have been struck by the remarkable want of relation between the physical properties of different samples and the ultimate chemical composition. It is very well known among foundrymen that irons which will give, say, ½ inch of chill, and are, therefore, approximately the same in chemical composition, are very far apart, many times, in their physical properties. The foundryman's tests for strength are, of course, crude, and the composition as determined by the chilling power is not definite, but when two different irons, which will give nearly the same chill under the same circumstances, differ in physical properties so widely, as is revealed by the ordinary method of testing pigs in the yard, even the most stupid observer cannot fail to recognize the difference. We ourselves have seen pigs of approximately the same size and giving approximately the same chill from different piles of iron, one of which would break when dropped from the height of the shoulders across an ordinary breaking block, while the others would require to be thrown with full force across the same breaking block three or four times before suffering fracture. To such an extent has this difference between the physical properties and the ultimate chemical analysis of pig-irons been observed, that many intelligent foundrymen do not hesitate to say that the chemistry of pig-irons is valueless, at least, for indicating anything in regard to strength.

In our work on pig-irons, in connection with the regular work of the Pennsylvania Railroad laboratory, we have run across the above peculiarity many times, not only in the pig metal, but also in the foundry product, and not a little study has been devoted to trying to solve the problem which has thus presented itself. With the firm belief that, when the chemistry of pig-iron is completely understood, it will prove of valuable assistance to the foundryman in his work, we have made many experiments trying to get a clew and an explanation of the puzzle. With a hope that the work already done may serve as an entering wedge, and stimulate others to take up this interesting problem, we present herewith the results of some of our experiments.

As showing how completely the ordinary ultimate chemical analysis of cast metal fails to explain, or even agree with the ordinary conceptions in regard to the relation between the chemical and physical properties, we subjoin the analyses of two cast-iron car-wheels. Both wheels were of approximately the same weight, both were cast in the same kind of mold, and, so far as could be judged by the condition of the wheels, both were poured at approximately the same temperature. One of the wheels had been in service, the other had not. One of the wheels, which we will call the good one, which had not been in service, required 150 blows with a 25-pound sledge to break a piece out. The other had been in service, and required 8 blows with the same sledge to break a piece out. We are well aware that the method of testing the strength of cast metals by sledging is not definite, but it is a practice very common at foundries, and, while it is impossible to draw fine distinctions, wide differences are as readily indicated in this way as in any other. One point further—hundreds of tests at the Altoona wheel foundry indicate that the service of a wheel makes no practical difference in the number of blows required to break a piece out, and we think it fair, therefore, to suppose that the poor wheel did not suffer in this respect from its service. A cracked wheel betrays itself with the first blow by the sound, and the poor wheel in this case was not cracked. The following are the analyses:

	Good wheel.	*Poor wheel.*
Total carbon,	**3.84 per cent.**	**3.53 per cent.**
Graphite,	**3.30 "**	**2.36 "**
Combined carbon,	**0.54 "**	**1.17 "**
Silicon,	**0.69 "**	**0.65 "**
Phosphorus,	**0.43 "**	**0.52 "**
Manganese,	**0.13 "**	**0.12 "**
Sulphur,	**0.12 "**	**0.19 "**

As will be observed from above analyses, the total carbon is 0.31 per cent. different, the larger amount being in the good wheel. The total silicon is only 0.04 per cent. different, the larger amount being in the good wheel. The phosphorus is 0.09 per cent. different, the larger amount being in the poor wheel. The manganese differs only 0.01 per cent., the larger amount being in the good wheel. The sulphur is 0.07 per cent. different, the larger amount being in the poor wheel.

The most remarkable difference is in the graphite and combined carbon, which, of course, vary inversely with each other—that is, in the same wheel, the higher the combined carbon the lower the graphite, and *vice versa*—but, to our astonishment, perhaps the highest combined carbon is in the poor wheel, whereas, with the ordinary conception of combined carbon, we expect greater strength to accompany the higher combined carbon. Perhaps, however, the most remarkable peculiarity of the whole subject is that, with two pieces of cast metal treated approximately alike, poured at approximately the same temperature, and cooled at approximately the same rate, with very slight differences in the total amounts of the other constituents, the combined carbon should be so extremely wide apart. No one can fail to be struck, we think, with this remarkable difference—0.54 per cent. in the good wheel, and 1.17 per cent. in the poor wheel—of combined carbon, and no one can fail to ask himself how it happens, under the circumstances, that the amounts of combined carbon in these two wheels are so different. Evidently some causes, as yet unexplained, determine the larger amount of combined carbon in the poor wheel, and also, so far as the indications of the ultimate analysis go, the very great difference in strength of these two wheels is, in some way, connected with this difference in combined carbon. In other words, there is not sufficient difference in any of the other constituents to account for it. We are confident no one accustomed to working on pig-irons would say that 0.09 per cent. difference in phosphorus, in a total of 0.52 per cent., would make so great a difference in strength.

We have made a very large number of experiments with these two wheels and upon other metal, including pig-irons, and we must frankly confess that we have not yet succeeded in finding anything that is completely satisfactory to us as an explanation of this puzzle, nor does our reading or study of the literature on the subject throw much light upon it. What follows, therefore, must be regarded more as a record of experimentation than as mature conclusion. The field opened is apparently broad, and there is very much need of work in this direction, and the principal object of this paper is to stimulate inquiry and get other workers into the field.

We find by treating fine borings with a dilute solution of hydrochloric acid—about 2.50 per cent. hydrochloric acid—that a part of the metal goes into solution and a part remains behind. In the two wheels above referred to, a larger percentage of residue is left in the poor wheel than in the good one. We have not followed out each of the elements completely yet, but, as far as we have gone, we find as follows: "A large portion of the metallic iron goes into solution, all the manganese goes into solution, and a portion of the phosphorus disappears and a portion of it stays with the residues." The sulphur we have not followed out completely, but a portion of it, at least, disappears. The silicon, apparently, all goes into solution, except, perchance, such as may be in the metal as slag. In working on other samples, we have found the silicon in the residue, however, excessively small, and conclude, therefore, the amount of slag in pig-metal is slight. As near as we can determine with the work we have already done, the residues consist in part of phosphide of iron, graphite, and separated carbon set free by the dilute acid. These, in amount, do not differ widely in the two wheels. A direct determination of the phosphorus in the residue from the good and poor wheels showed in the good wheel 0.30 per cent., and in the poor wheel 0.32 per cent. Also, there are strong indications that all the carbon, or practically all the carbon, remains in the residue.

In addition to the phosphide of iron and the carbon, we find in the residue what is apparently a compound of iron and carbon, and may, perhaps, best be called carbide of iron. The amount of this carbide of iron is different in the two wheels, being by far greater in the poor wheel. This carbide is gray in color, and apparently granular in structure. It seems to exist in the cast metal as little granules breaking up the continuity of the metal. We have not yet succeeded in determining the composition of this carbide of iron, nor have we yet succeeded in finding methods that would enable us to distinguish between the amount of carbon in this carbide and the graphite and the carbon, if any, set free by the dilute acid. There seem to be indications of two things:

1. That the carbon in pig-irons exists in three forms, namely, as graphite, as carbide of iron, and, possibly, as combined with the iron in the same way that it is combined with the iron in steel, a form which we may venture to call "strength carbon."

2. There are indications that the carbide of iron before referred to is the principal cause of the great difference in strength between the good and poor wheels.

If, on more mature study, these two statements should prove to be correct, it would seem that the constitution of pig-iron—and, in fact, of cast-iron in general—would not be very difficult to explain. The iron might be regarded as made up of strength producers and weakeners, the strength producers forming the frame-work of the mass of metal, and the weakeners being interspersed through the mass in a more or less granular or crystalline form and interfering with its continuity. The metallic iron, the metallic manganese, the silicon, perhaps, and the strength carbon may be regarded as the strength producers, while the graphite, the phosphide of iron, the sulphide of iron, and the carbide of iron, together with the slag and oxides, if any are present, might be regarded as the weakeners. It is not difficult to conceive, we think, that any granular body, be it a grain of sand, a grain of graphite, a grain of crystallized phosphide of iron or sulphide of iron, or a granule of carbide of iron, occurring in the mass of either a piece of steel, a piece of wrought-iron, or in any alloy composed of metallic iron, manganese, silicon, and carbon, would, by its presence, interfere with the continuity of the metal and diminish its strength. If, in addition to the graphite, the phosphide of iron, and the sulphide of iron, which have for a long time been known to be present in pig-irons to a limited extent, it should be found that a granular carbide of iron is also a constituent, we cannot help thinking this same carbide will throw much light on the very wide difference in different samples of cast-iron. We have treated a large number of samples, both of pig and cast metal with a dilute acid as before described, and we find this gray granular carbide, so far as can be determined by the eye, always present, and always larger in amount the poorer the metal. As previously stated, however, the methods for determining the amount of this carbide and the amount of graphite and strength carbon have yet to be worked out. Of the existence of the carbide, there seems little doubt. Duplicate tests on the same sample, with exposure to the acid for different periods of time from four to twenty-four hours, give approximately the same total residue unacted on. In other words, there is strong evidence of the existence of a compound of iron and carbon which is insoluble in 2.50 per cent. hydrochloric acid.

There are very many interesting questions which might be asked, and undoubtedly will occur to all. Answers to these questions will have to be obtained by further study. The most important one, perhaps, is: Why does this carbide form in certain irons and not in others? There are indications that it is characteristic of repeated meltings in the cupola, and there are also indications that the presence of basic slag prevents its formation.

It is earnestly hoped that deep study will be put on this interesting problem. The commercial results connected with it are something enormous. Some furnaces uniformly make strong irons, others uniformly weak irons. Is it not possible that a change in practice which would diminish the amount of carbide of iron would change the weak iron to a strong one? Also, as is well known, scrap can only be used to a limited extent in foundries. If we knew how to prevent the formation of this granular carbide of iron, is it not possible that scrap could be used to a very much greater extent than at present? We are confident that the man or men who first explore this field and give us a complete understanding of the constitution of pig-iron, as well as a method of controlling its composition, will certainly cause iron metallurgy to take an enormous stride forward.

This was followed by a paper on the "Microscopical Structure of Car Wheel Iron," by Mr. F. L. Garrison, of Philadelphia. Mr. Garrison's paper was in continuation of Dr. Dudley's, and was illustrated by microscopical photographs of the iron thrown upon a screen by the use of a lantern. This paper requires the reproduction of the microscopical photographs, which we hope to present to our readers in a future issue; together with the discussion of the paper, in which Mr. S. A. Ford detailed his investigations concerning the chilling properties of cast-iron, as published in the JOURNAL, Vol. I, No. 1, page 31, pointing to a combination of carbon and silicon as the possible cause of the chill.

Charcoal Iron in Great Britain.

1725—1731.

An appendix to the *Journal of the Iron and Steel Institute of Great Britain*, for 1885, consists of a reprint (in imitation its quaint typography, orthography, and phraseology) of an anonymous tract printed in England between 1725-31.

The data concerning the methods and output of that time, and the consternation which the development of the iron industry of America seemed to cause, as well as the political features of the tract, have encouraged us to present liberal extracts in the JOURNAL. Want of space is our apology for not reprinting the entire tract, but those who desire to follow the matter further, can refer to *Journal of Iron and Steel Institute, No* 2, 1885.

The tract is entitled :

THE INTEREST OF GREAT BRITAIN IN SUPPLYING HERSELF WITH IRON: IMPARTIALLY CONSIDERED.

Iron-Ore is not to be converted with Advantage into good malleable Iron with any other Fire that we know of, but what is made of Wood, Chaikt or Charcoal. The first matereal Alteration it undergoes, is in the *Furnace*, wherein it is melted, becomes a fluid Substance, and is let out into Gutters made in Sand. All iron in this state is brittle and unmalleable, not capable of being manufactured, or worked into any other Shape than what it is cast into, and consequently adapted to few Purposes.

Pig-Iron is brought from the *Furnace* to the *Forge ;* and there by being melted and digested in the Fire becomes a fixt and malleable Substance; and by repeated Heats in the Fire, and repeated Impressions of the Hammer, is beaten out into long Bars or Palasades, and upon that account is termed Bar-Iron.

Bar-Iron is distinguished by particular Names according to its Dimensions and Uses. The two most general are *Merchant-Bar* and *Mill-Bar:* The one being such shaped Iron as is usually imported by the Merchant, about Inch and a half or two Inches broad and one third thick, and squares of different Sizes. The other such as is proper for the *Slitting* or *Rolling-Mill*, of double Dimensions to the former. The *Slitting* and *Rolling-Mills* are Water-Engines, whose Use is to reduce Bar-Iron into small Rods or thin Plates, in order to save the Expence of Charcoal and Human Labour.*

* * * *Hardness* is that Quality of Iron, whereby it yields not easily to the Stroke of the Hammer when Hot, nor to the friction of the File or other fretting Instrument, when *Cold*, *Softness*, the contrary. Of Hardness partakes more or less all the Iron imported from the *Baltick*. Of *Softness*, all the *British* and *American*. *Toughness* is that quality of Iron, whereby it is not easily broken by bending: and Brittleness is the contrary; the highest Degree of which is, when it will not bend at all, but snaps a sunder like Glass. This sort of Iron is termed by *Mechanicks Cold-short*, in opposition to another vicious Quality of some Iron, which is termed *Red-short*, because, when red hot, it cracks and falls to pieces under the Hammer. Iron of a middle Nature between *Tough* and *Cold-short*, is termed Ordinary if it approaches towards Tough, and Blend if it approaches towards Cold-short; and admits of all Degrees of one or the other Quality. * *

* * * Iron is converted into Steel, by being put, (with pulverized Charcoal along with it,) into a large Crucible, and there heated for a considerable Time by an external Fire, the Mouth of the Crucible being closely stop'd. All Iron is supposed to be convertible into some sort of Steel or other. The *Swedish Orground Iron*, tho' the best that we can get, is not the best in the World for this Purpose: the *German* Steel vastly excelling what we make, which is attributed not to any difference of skill in the Conversion, but to a Natural difference in the Iron converted.

* * * That *Great Britain* does not supply herself, (Steel only excepted,) is not owing to any natural Defect or Incapacity. Not to want of Ore, for in that respect Nature has been very Liberal. *Cumberland* and *Lancashire* are supposed capa-

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***Mill-Bar is often drawn out with a Pitcoal Fire, but if with Charcoal, does not require near the same quantity as fine Merchant-Bar, which is capable of being drawn out with a Charcoal Fire only, Consequently these Engines where Charcoal is as expensive as in *Great Britain*, are of the utmost Importance; but in such Countries as *America* where Charcoal is so exceeding plenty, Iron might be so minutely hammer'd out at the Forges, as to render these Engines of no such Consequence, but that a Manufactory may be very well carried on without them.**

ble of answering the Purposes not only of this Nation, but even of the Universe. * * * The true Causes of this Deficiency are: First, The Woods of this Kingdom were grub'd up and destroyed, at such time when they were esteemed an Incumbrance, and when the Consumption of Iron was very inconsiderable to what it is at present. That Woods were formerly an Incumbrance, is evident from the Statute of *Winchester* of *Edward* 1*st.* wherein it is supposed that the Lord of the Soil might not be able to cut down the Underwoods adjoining to the Highways, and in such case it is provided, that the Country shall assist them. Now admitting that Woodlands would answer better than other Lands of the same Nature and Goodness clear from Wood; and admitting that Ore and every thing else except Wood necessary to the Formation of Iron, lay convenient and at hand; and that a sufficient Quantity of Land adjoining were proper for the growth of Wood, and would be more profitable to the Owners by being planted than in any other way. Yet how few Persons are capable of staying fifteen or twenty Years without any Returns which must be the Case of the first Planters? How impossible is it for so many to agree together, as are capable of planting a Quantity sufficient for a Forge and Furnace? And how improbable is it. That this should be done upon an uncertain Expectation of Iron-works to be erected fifteen or twenty Years after, which is as soon as the Wood will be ready? It is very evident that nothing less than the Legislative Power is capable of undertaking a design of this Nature, of erecting Iron-works in a Country where the Woods have been once destroyed. So that if we suppose *Great Britain* formerly to have supplied herself with Iron, yet upon so large Increase of the Consumption, and the unsurmountable Difficulties attending a new Erection, where there are no Woods to begin with, she must by necessity, (tho' the whole Island were but one Mass of Iron Ore.) have been obliged to seek Supplies from Abroad.

The other and principal *Cause* why we cannot supply ourselves with Iron, arises from the greater plenty of Gold and Silver in *Great Britain*, than in the Northern Countries: And consequently the prime Cost of Iron to the *Swedish* Maker cannot at most be above four or five pound *per* Ton, which to the *British* Maker is fifteen or sixteen Pounds. The *Swedish* Iron is indeed sold at the Ports in *Sweden* from nine to ten pounds; But this Advance of the price above the prime Cost, is owing to the Profits of the Makers and Others thro' whose hands it passes, to the charge of Carriage, and to a large *Swedish* Duty equivalent to three Pounds twelve Shillings and six Pence *per* Ton. As Labor and Land and it's Products are but of one fourth Value in *Sweden* of what they are in *England*, so we may suppose, that in some Provinces of the *Russian* Empire, they may not be above one fourth of what they are in *Sweden*. How otherwise shall we Account for the surprising Circumstances, of Bar-Iron made in *Siberia*, brought almost cross one fourth part of the Terrestrial Globe, and by an Inland Carriage of four thousand Miles, to the Port of *Petersburgh*, and there sold at so low a price as seven or eight Pounds *per* Ton. Our astonishment vanishes by considering, that, the value of Gold and Silver being reciprocally proportional to their Quantity, it is possible for one Ounce of those Metals to go as far in one part of the World, as twenty, thirty *&c.* Ounces will in another. The prime Cost of *British* Iron to the Maker being from fifteen to sixteen Pounds *per* Ton; and the Northern Iron, allowing two Pounds for Duty, being to the Merchant but from nine to twelve Pounds; and the Freight from the *Baltick* lieing the Merchant in no more than what it will cost the *British* Maker to carry his Iron but twenty Miles by Land-Carriage; it is very plain, that tho' *Great Britain* were ever so well stored with Woods and every other material Necessary to the Formation of Bar-Iron; yet, (as Things are at present) that the *British* Maker would be undersold by the importing Merchant, in *Swedes* Iron, tho' the price of Cordwood were as low again as it now is; and in *Russian*, tho' the Woods were had for the falling only.

Indeed this is not the Case; the Woods of *Great Britain* are very much reduc'd: And the Reason is plain: People have been too wise to permit their Lands to be over-grown with so improfitable a Crop. There is no Woodland, (except some very stony or very unlevel Ground, and thereby unfit for Plow and Pasture,) but what would bring in, were it cleared, one, two or three Shillings more *per* Acre Annually, than it now does by Cordwood.*

*** An Acre of five Shillings *per Ann.* value is supposed not to produce above ten Cords in twenty Years, that is but four, three or two Shillings *per Ann.* according to the different Prices of Wood, the Herbage will not pay the Tythe, Charge of Fencing, &c.**

* * * We need not call in the *Americans* to their Assistance; the *Swedes* and *Russians* alone are sufficiently able to subdue the British Woods and Iron-works.

And yet the making of Bar-Iron is no such inconsiderable Branch of Trade as some may imagine: Tho' it be distinguished from the working of Bar-Iron into Wares, which carries the Name of the Iron-Manufactory, yet is itself a very considerable Manufactory: It requires and maintains more Hands *per* Ton, than the working of it afterwards into Nails and other coarse Wares.* It has been computed (and we believe with Fidelity) that within some few Years past, there has been made in *Great Britain* Eighteen Thousand Ton *per Ann.* There are Works yet in Being sufficient for that or even a larger Quantity. The making of Eighteen Thousand Ton of Iron, is the Support and Employment of Twelve Thousand Hands and Twelve Thousand Families: It affords an Expense of Two hundred seventy Thousand Pounds *per Ann.* in the Countries where the Works are situate; the absence of which so large a Sum by the Destruction of the Works, must not only affect the Woodlands and Coppices, but the Rents of all other Lands in those Parts, and sink the value of their produce; must be the Ruin of Thousands and the Impoverishment of All.

British Timber labours under the same Disadvantages as British Iron; it is undersold by Deals and other Foreign Woods: Calculate the Value of the Land it Shades for a Century or Two; and it will by no means answer us or our Posterity for the Preservation of it: How much less will it do this, when the Tops and Buts, which now cut into Cordwood, are of one third Value of the whole, will then become Useless and of no Account? And where shall the British Oak be preserved, when the only Nurseries of it the Coppices which are now supported by the Ironworks, and where

---

***The charge of Wood and Ore and Rent of Works in a Ton of Iron valued at Sixteen pound does not amount to above four pounds five shillings, the remainder eleven pounds fifteen shillings is Labour and Carriage so that Labour exclusive of all other Charge must be at least nine pound *per* Ton, and the making of three Tons must employ at least two Hands of such Labourers as are made use of in that way whereas a Nailer in most sorts of Nails will work up two, three, four or five Tons *per Ann.* Again, a Nailer pays for his Coal, makes good all waste of Iron and yet converts Iron into Nails under one penny per pound one sort with another, whereas Labour itself in making a Ton of Iron comes to near as much.**

the Use of Pit-coal prevails, can be supported no otherway, are grub'd up and destroyed? *Great Britain* now not only supplies herself, but *Ireland* likewise with Oak-bark for Tanning of Hides, and converting them into Leather. Should the Coppices be destroyed, (and surely they are not worth preserving for the sake of the Bark only,) she and her Sister *Ireland* must both go a begging for it Abroad; no doubt there are those who will be very ready to supply us; there is enough in *America*, it will ride very well along with *American* Iron, and increase our Trade and Navigation: According to some Men's way of thinking, it is our Interest to have every Thing from Abroad.

* * * * * * *

What has much contributed (amongst other Things) to support the *British* Iron-works against the Inundation of *Northern* Iron, is, (as we observed before,) the soft Nature of our *British* Iron, upon which Account it is more proper for several Uses, and Sells for a better Price. But the *American*, (as appears by what has been imported in Bars from thence, and likewise by what has been refined from Pigs here,) is of the same soft Nature as the *British*, and consequently being imported must first supply the place of the *British*, before it can any way affect the *Swedish* or *Russian*. And as the *American*, (as appears by the Evidence of our Adversaries,) cannot be afforded so cheap as the *Swedish* and *Russian*, of Consequence the Importation of it must affect the *British* only, but will not be capable in the least of supplying the place of the *Swedish* and *Russian*. But suppose we admit the *American* might be imported as Cheap or Cheaper than the *Swedish* is at present: The Event would be, that the *Swedes* would be obliged to lower or quite take off their own large Duty; and then even upon this Supposition would be enabled greatly to under sell the *American*. The Scheme therefore of Importing Bar-Iron from thence, as to any Advantagious purpose (as things are at present) is utterly impracticable; and will serve to no other End but to destroy the *British* Woods and Iron-works, and to diminish the British Manufactory.

Formerly our Colonies were entirely supplied with Iron and Iron-ware from hence: But since the erection of Iron-works there, *New-England* now not only furnishes herself, but the other Colonies likewise with sundry sorts of Iron-wares. The Erection of more Forges, will naturally produce more Manufactories: and the *Americans* will soon supply themselves with every thing in that way, which now they have from *Great Britain.* We are told indeed that they are forced to Manufacture by Necessity, that is Poverty. The *American* Manufacturer, by the Cheapness of his Iron, and by saving the many Expenses, Disappointments and Damages, that British Iron-wares must necessarily be attended with in their Conveyance thither, (if we suppose Coal and Labour to be the same there as here,) will get, by selling at an equal price with the British Manufacturer, besides the reasonable Profit common to both, a particular Gain of at least ten pound per Ton. Besides this, he had lately and probably now has a large prœmium allowed him for Nails and Scythes by the Government of *New England*, payable out of their publick Treasury.

The *American* Scheme therefore, by destroying the British Ironworks, will lose this Nation above two Hundred Thousand pounds and, by ruining that part of our Manufactory, which now supplies *America*, one Hundred Thousand pounds more: But by not being capable of injuring the Northern Works will not any way lesson that large Ballance we now pay to *Sweden;* but probably oblige us in a short time to pay an equal or larger Ballance to our own Plantations. Instead of rend'ring *Great Britain* independent of her Northern Neighbors, it will rather render *America* independent of *Great Britain;* and subject *Great Britain* to a double Dependency. It will take the Bread in effect out of the Mouths of several Thousand British Families, and give it to barbarous Herds of Criols and Negroes. Lastly, It will sink our Rents; destroy our Coppices; discourage the preservation of Timber for the Navy; and Bark for the support of the Leathern Manufactory; in order only to Improve and Cultivate the *American* Forests: Countries which in Time to come will have no more Regard to *Great Britain*, than we now have for the Native places of our *Saxon* Ancestors.

It must be confessed indeed, that tho' the *American* Scheme be laid aside, yet our Iron-Trade thither cannot long subsist without a Suppression of their present Forges, or at least a prevention of erecting more. For the many Furnaces, already erected in those Parts, will naturally produce Forges, and Forges Manufactories. Many a person will now be able to erect a Forge, who could not have erected both. A person, by erecting a Furnace and Forge at once, would have run a very great risque: His Iron might be Red-short, and fit for none, or Cold-short, and fit for but very few Purposes: Whereas now, the Nature of the Pigs being already explored, this Hazard is wholly avoided, and a Forge erected upon sure Grounds. Any run-a-gate Artificer, planting himself by an *American* Forge, will, where the advantages are so great, as naturally produce a Manufactory; as an Acorn sown in a proper Soil will an Oak. Had the Erection of Forges been prevented, or could those already erected be suppress'd; instead of sending there two thousand Tons of Iron-ware, we should send a double or treble Proportion; and should likewise have hit of a sure Expedient of keeping those Provinces dependent on us, and the Ballance of Trade on our own Side. These Purposes may in some measure be answered, by preventing for the future any new Erection.

* * * *

A Forge is a thing of Publick Nature and what no man has Occasion to erect, for his own private Use; and consequently the hindering of it, would not savour of Tyranny; and its Magnitude and Noise will expose it to an easy discovery. The Iron-Trade therefore to *America* is, what we might have been sure of keeping in our own Hands, when all other Things might fail.

But the Suppression of the *American* will not preserve the *British* Iron-works. These cannot be supported but by an Advancement of the price of Iron. The scarcity of Wood is not the Cause of the decay of our Iron-works; but the consequence only. The cheapness of Iron has caused a cheapness of Wood, and the cheapness of Wood has caused a neglect in the Planting and Preservation of it. The Beauty and Ornament of Woods to an estate; the Refuge and Protection they afford to Game; their Fundlike nature, from whence may be drawn large Sums at once to answer any emergency, with several other Advantages, would not fail of encouraging the Planting and Preservation of them; were they but equally profitable with other Lands of the same Nature and Goodness. That a proper Advancement of the price of Iron, would raise the price of Wood and make such Lands profitable, is evident from what happened in the time of *Swedish* Prohibition; when Cord-wood sold in most parts of this Kingdom at a double Rate to what it now does. And as by this means the making of Iron, as well as the raising of Wood, would become each advantageous, it is not to be doubted, but our Woods and our Iron-works would gradually increase together, till at last we arrived at a true State of Independency for so useful a metal; and should no longer depend upon the Winds, and Seas and Humours of other Nations for a Commodity so essential to the Security, Well-being, and Happiness of any People.

* * * The price of Iron might indeed be advanced by a nice Limitation of the Quantity to be imported Annually. But the more ready and certain Method, will be the laying of a further Duty upon Foreign; The Produce of which being converted into a Prœmium upon *British*, will work both Ways; the Quantity of the Duty, and the Inconveniences arising therefrom will be but one half; and the Effect double. The Objection of Frauds attending Prœmiums will not here take place, because the Quantity which a Forge can Annually make is well known; Besides the Workmen are paid per Ton; and the book by which they are paid will shew what is made. An increase of British Iron would soon be felt in *Sweden ;* by a decrease in our Demands from thence: And as the *Swedes* are a free People, and the Iron-Trade, their main support; their Government would be obliged to lessen, and in Time quite take off their own duty of three pounds twelve shillings and six pence per Ton, in order to undersell the British, and revive their drooping Trade: And this effect of our Scheme alone, would save Great Britain upwards of sixty thousand pounds of that Ballance which she now pays, admitting we took the same Quantity, as we now do: And by an Additional Duty, in the place of the *Swedish*, which will, as that goes off, become necessary to support our own Iron-works; we shall in time by these Means pay this large Sum towards the support of our own Government, which we now do to the support of the *Swedish :*

* * * * * *

A SQUARE acre requires 50.6 rods of fence to inclose. It has been stated that from one-quarter to one-eighth of the present fences of the country would be amply sufficient to keep stock within proper limit.

British Furnaces in Blast.

Several of the trade papers here publish returns of the condition of the blast furnaces in Great Britain. Curiously enough, their figures are all different. Some of them are certainly erroneous, as they include furnaces, to the number of between 20 and 30, which have been pulled down or dismantled for years past. Taking the statistics of the *Ironmonger* to be nearest the truth, we have the following results:

General Summary.

Total number of furnaces existing January 30, 1886,	**855**
Total number furnaces idle January 30, 1886,	**439**
Total number of furnaces in blast January 30, 1886,	**416**
Total number of furnaces in course of erection January 30, 1886,	**6**
Total number of furnaces on the ordinary pig-iron of the various districts,	**320**
Total number of furnaces making hematite pig-iron,	**86**
Total number of furnaces making spiegeleisen,	**8**
Total number of furnaces making basic, or siliceous, pig-iron,	**2**

The same paper makes an attempt to give the stocks on hand, but that is obviously somewhat difficult. From the remarks published, however, the stocks appear to be moderate, on the average. —*Ex.*

A DEALER in bark in Virginia made a contract with R., a tanner in New Jersey, to send him one car-load of bark weekly until a certain quantity was delivered. Five car-loads were delivered, accepted, and paid for without objection, but when the sixth load was about to be sent on, R. requested some delay, and B. was prevented from making further deliveries only by the peremptory refusal of R. to receive any more bark from him. B. protested, proposed an arbitration, and finally brought action and recovered. In this case, the defendant carried the judgment to the Supreme Court of New Jersey, and then to the Court of Errors and Appeals of New Jersey, where it was finally affirmed. Judge Dixon, in the opinion, said: "The rule is that defaults by one party in making particular deliveries or payments will not release the other party from his duty to make the other payments or deliveries stipulated in the contract, unless the conduct of the party in default be such as to evince an intention to abandon his contract or a design no longer to be bound by its terms."

GOOD WORK BY THE GIRARD FURNACE.—We have received from Mr. Henry B. Shields, manager of the Girard Iron Co., of Girard, Ohio, the following statement, in tons of 2,268 pounds, of the weekly output of pig-iron by the Girard furnace in the last 6 months of 1885:

WEEK ENDING.	Tons.	WEEK ENDING.	Tons.	WEEK ENDING.	Tons.
July 4, ...	585	Sept. 12, ...	1,017	Nov. 21, ...	1,048
" 11, ...	985	" 19, . . .	984	" 28, ...	1,018
" 18, ...	735	" 26, ...	464	Dec. 5, ...	1,024
" 25, ...	665	Oct. 3, ...	739	" 12, ...	983
Aug. 1, ...	1,095	" 10, ...	339	" 19, ...	941
" 8, . . .	1,050	" 17, . . .	422	" 26, ...	1,026
" 15, ...	1,106	" 24, ...	1,000	" 31, ...	691
" 22, ...	568	" 31, ...	1,020		
" 29, ...	1,066	Nov. 7, . . .	901	Total, ...	23,600
Sept. 5, ...	1,116	" 14, ...	1,012	or, net tons, .	26,762

The dimensions of the furnace are 75 feet height, and 16 feet diameter at bosh. The ore used was exclusively Lake Superior ore, and the fuel was exclusively Connellsville coke.

◆

THE Secretary of the Treasury of the United States has approved of the following rule for testing boiler iron and steel:

RULE I.

SECTION 6. To ascertain the ductility and other lawful qualities, iron of 45,000 pounds tensile strength and under shall show a contraction of area of 15 per cent., and each additional 1,000 pounds tensile strength shall show 1 per cent. additional contraction of area up to and including 55,000 T. S. Iron of 55,000 T. S. and upward, showing 25 per cent. reduction of area, shall be deemed to have the lawful ductility.—(Sections 4,430 and 4,431, Revised Statutes.) *All steel plate of one half inch thickness and under shall show a contraction of area of not less than* 50 *per cent. Steel plate over one half inch in thickness shall show a reduction of not less than* 45 *per cent.;* Provided, however, *That steel plate required for repairs to boilers built previous to April* 1, 1886, *may be used for such repairs when showing a contraction of area of not less than* 40 *per cent.*

Relative Strength of Wet and Dry Timber.

In reply to a statement by the *American Miller* that "wet timber is not as strong as dry, in some cases it has not half the strength of dry," a correspondent of that paper writes as follows: "In September, 1876, the Lanesboro' mills, Minnesota, were rebuilt, and began making flour the next March. We used sawed pine (taken out of the Mississippi river) for joists, 3 × 12 inches, 12 feet long, and sized them, laying them on top of the girders to get their full strength, and then used ⅞-match flooring. The joists were placed 12 inches from center to center, leaving 9 inches between them. In the fall of 1877, we piled wheat on the floor 26 feet deep in the bins, and the joists, yet wet and green, only sagged a trifle, and carried the immense weight safely. Two years later, the same joists were dry, from the heat of our very large stove. We loaded the floor with 24 feet of wheat, and six joists broke off nearly square in the middle, and others were cracked. In the first instance, the bins held 360 tons of wheat while the joists under them were green. When the joists were dry, 300 tons or less broke several of them. This shows that green pine is stronger than dry pine, as the wood becomes brash and brittle by drying, and is not as strong as when green. This is caused by the sap drying and leaving only solid matter in the capillary tubes, and they cannot move one on another, while if the timber is green the tubes are full of water, and can bend or move one on another. I know of but two kinds of wood that are stronger dry than green, and they are maple and white oak."

◆

IN describing a trip through the gold mines of Georgia, Mr. Henry G. Hauks says: "Passing Cherry Log, (Ga.,) at an elevation of fifteen hundred feet, we reached a deposit of limonite iron ore, which had the appearance of being worked. I found no regular deposit, but an open cut into a red hill not more than a hundred feet long nor over ten to fifteen feet deep. In the red earth, however, there were nodules of limonite, but not very abundant. Near a sluice-box, at a small running stream near by, I found where the ore was being washed, and the nodules separated and laid up in a small pile.

The nodules of limonite are gathered and hauled to Hemptown, near Morgantown, where there is a rude forge, consisting of a trip-hammer, driven by water, and a furnace. The fuel used is charcoal. The ore is heated and hammered, returned to the furnace for a second heating, and again placed beneath the hammer. This process is continued until soft, malleable, and tough iron in bars is obtained, which are used by the local blacksmiths for making horse-shoes and other common iron work. The capacity of the works is only twenty-three tons of soft iron in a year. The manufactured iron is sold at three cents a pound. This makes the value of the entire output of the furnace $1,380 per year. I asked the owner of the mine how much he received per ton for his ore, upon which he informed me that he hauled it to Hemptown and received at the forge 12½ pounds of soft bars in return for each ton of ore delivered. This, at three cents per pound, netted him 37½ cents per ton."

COST OF MAKING COKE.—The following is an estimate published in one of the daily papers of Pittsburgh by a miner, and represents the daily expenses of a bank of 40 ovens, 20 being drawn each day:

Cost of coal, (½ cent per bushel,)	$12 35
70 cars of coal, @ 27 cents,	18 90
Charging ovens,	2 00
Leveling,	1 60
Drawing 20 ovens,	11 00
Hauling and feeding stock,	2 75
Boss's wages,	2 00
Oil, posts, rails, etc.,	1 50
Interest on capital,	2 50
Syndicate's commission for handling coke,	3 65
Total,	$58 15
58$\frac{8}{10}$ tons of coke, @ $1 20,	$70 56
Less daily expenses,	58 15
Balance,	$12 41

This makes the cost of putting a ton of coke in the cars, ready for shipment, 98$\frac{9}{10}$ cents. An estimate of the cost by a manufacturer is as follows:

Coal for a ton of coke,	$0 38
Drawing and loading,	25
Hauling and incidentals,	10
Repairs,	10
Total,	$0 83

Add interest on capital, and allowance for coal used, 32 cents; total, $1 15.

T. P. Langdon
Port Henry N.Y.

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OF THE

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Devoted to discussing and illustrating improvements in iron metallurgy, or in the manufacture of charcoal.

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Edited by JOHN BIRKINBINE, Secretary,
No. 152 South Fourth Street, Philadelphia, Pa.

ARTICLE V. — Constitution of the United States Association of Charcoal Iron Workers.

Any person practically engaged, or interested, by reason of capital invested, in making or using pig-iron or blooms made with charcoal may become a MEMBER of the Association by paying an annual fee of five dollars ($5.) *Provided*, That each iron works represented shall pay not less than ten dollars ($10) per annum into the treasury.

Persons not engaged in making or using charcoal pig-iron or blooms may become ASSOCIATES, without the right to vote or hold office, upon the payment of an annual fee of five dollars ($5) each. All fees to be due when the membership is applied for, and thereafter on the first day of October in each year, being in advance.

All communications should be addressed to the Secretary of the Association.

Improvements in Iron Metallurgy.

Were it possible to trace the outlay devoted to the various improvements in plant or process connected with the production of pig-iron, we would probably have to start with a large debit account for each particular feature. This is not remarkable when we realize that such expenses are necessarily parts of a system of development, but, evidently, this cost would be much reduced were it not for the imitative nature of humanity. We are apt to accuse women of being slaves of fashion, but they do not follow more blindly than men often do what others suggest, and we venture the assertion that *fashion* has caused the failure of many iron works. Not the fashion which demands reproduction of certain forms of ornamentation, but that following after others without due consideration; adopting every new feature without *adapting* it to surroundings.

When the hot-blast stove was found advantageous for the blast furnace it was considered that it would only be necessary to add a stove to any plant to improve it; such, however, was not the case. and a furnace so proportioned as to give satisfactory results with cold blast may be thrown out of equilibrium (if we may so express it) by adding a hot oven and making no other changes. Gradually the temperature of the blast was raised from 300° to 600°, then to 900°, 1,200°, and 1,500°, or even higher, but a reaction has resulted, and a blast of 1,200° is seldom regularly employed with the newer forms of regenerative stoves. So the older furnaces were increased in dimensions until immense structures, 30 feet in diameter at bosh and 110 feet high, were erected in England. Now, however. a diameter of 20 feet and a height of 80 feet is only occasionally provided, and few plants have, up to date, reached even these dimensions in this country.

The saucer-like flat boshes of the older charcoal blast furnaces, resting upon a contracted but high crucible, were gradually steepened and the crucible widened until in many cases the slope of about two inches to a foot extended in a direct line from the top of bosh to bottom of the furnace, and crucibles of over half the area at bosh were constructed. The steepening of boshes resulted in an experimental "no bosh furnace," with practically vertical walls. Now, however, it is the *fashion* to flatten the boshes, and we may find this also again carried to extremes. In another article we show various slopes of boshes which will illustrate the relative angles.

We might follow the blast furnace practice through all its features and show how the number of tuyeres were increased to an impracticable maximum and then reduced to more moderate limits, or how the size of the charge ran to extremes, either of liberality or of contraction, or how, too often, the prevalent idea seemed to be that "if a thing is good a great deal of a good thing is better."

The patent office overflows with caveats and claims, issues and re-issues for improvements in iron metallurgy, and a continual furore about infringements is kept up; the great mass of the inventions being for plants or processes which were long ago tried. Many inventors would be surprised, or, if not surprised, chagrined to have pointed out to them in some of the older works of encyclopædic character the original of their "original" ideas.

The political or semi-political character of appointments to the staff of the United States patent office prevents as thorough knowledge of details by officials as is desirable, and the mere approval of an examiner really carries little protection to an inventor. In fact, few patents issued have little intrinsic value until they have been tested in court. Hence, a multiplicity of patents and an army of inventors, most of them confident of reducing cost 50 per cent., or augmenting output 100 per cent., and each eager to have the method tested at another's expense.

We would not be understood as belittling inventive genius, on the contrary, we desire to fully appreciate it; but we claim that a patent does not, *per se*, indicate an invention, nor are all inventions improvements, or even novelties. Neither would we appear as failing to recognize the merit of improvements in process or plant, which have done so much to advance the practice of iron metallurgy.

We might remark, parantheticaily here, the fact that most of the improvements in process which have become commercial or financial successes are of foreign origin, few of the notable ones being American inventions; on the other hand, mechanical features, which improve the results obtainable from these metallurgical processes, are largely of American origin.

Our iron works have not been slow to experiment with novelties; perhaps they have been too ready to introduce new features without a thorough study of their adaptability for the special locations or purposes for which they were used. That such have been the case in many instances, all our readers know, from the *modern* plants which have been financially unsuccessful while neighboring *old fogy* works have paid dividends, not because, in every case, the improvements were of no advantage, but oftener because they were "adopted rather than adapted." The desire to rapidly introduce patented specialties and collect the royalties for their use has done much to injure some very meritorious inventions, by cheapening the cost of construction beyond the limit of judicious economy, a course which, by the repair bills, soon condemns otherwise good inventions or appliances. This cheapening is accomplished either by reducing the number, capacity, or power of these specialties, or by using material in construction which is not conducive to permanency.

To determine as to what are judicious improvements, adapted to special circumstances, is not a mere matter of sentiment; in fact, the trouble is to separate the sentimental from the practical; to analyse the claims of merit, sifting out the enthusiastic indorsements, or promises as yet unfulfilled; to figure out in dollars and cents the advantage or disadvantage of each claimant for recognition. The failure to thoroughly consider all these points has been the reason for many disasters when success was confidently expected to result from changes made.

One prolific cause for these errors is attributable to a parsimony which dictates that outside assistance is unnecessary, and that the iron works possesses all the ability necessary to plan and adapt improvements. In many instances this is true, and among the managers of iron works are some of the best skilled metallurgists of which the country boasts. But, in a majority of cases, a manager is so tied down to his routine work that he has little opportunity to judge of the proper application of the processes or appliances in use elsewhere, and, although ably efficient, he is restricted in his investigations to the narrow field which commands all of his time. It is not unnatural for men so situated to become enthusiastic upon novelties of the merits of which they are kept posted, but with little or no opportunity to see the disadvantages attributable to their use. Having been influential in securing the adoption of any of these features, a manager is naturally its champion, or at least its apologist, and his indorsement is sufficient for a neighbor to make a similar venture. In this way the fashion above referred to has largely developed, and many good ideas have been brought into ill repute by misapplication, while other features have been adopted upon claims of merit which practice has failed to substantiate.

At short intervals we hear of inventions or methods which will revolutionize the iron and steel industries, but true progress comes from continuous investigation, persistent study, and care in the application and operation of methods or machines. To our notion, the manager of an iron works should be ready to investigate all reputed improvements, but his investigation should be a critical one, and should have especial bearing upon the conditions existing at his works.

That the opinions above expressed are applicable elsewhere than in our own country may be noted from the following remark of Sir Lowthian Bell in his book upon The Iron Trade in the United Kingdom, page 99:

"It is impossible to over-estimate the advantages obtained by scientific training, not only for the purpose of pursuing what is really good in theory, but in rejecting what is absolutely fallacious. With a little more learning than is frequently possessed by a crowd of patentees, much money and some time would have been saved to British as well as foreign speculators. At the same time, we cannot fail to be struck with the good fortune which has attended the efforts of many inventors, particularly those of Great Britain, in this branch of industry long before the value of applied science was recognized as it is now."

THE acting superintendent of the Coast and Geodetic Survey states that Congress has never made any enactment establishing standards of weights and measures for the United States, except in case of the Troy pound, and that all our standards have become so by usage only, having been in use in the various Colonies prior to the Revolution.

The Iron Ores of Maine.

By O. W. DAVIS, Jr.

While there are numerous small deposits of limonite and magnetic ores known to exist in Maine, the only ones of any, at present, commercial importance are those at Katahdin iron works, in Piscataquis county, and the beds contiguous to the Aroostook river, in Aroostook county.

The measures in the vicinity of Katahdin iron works are silurian clay slates, which run, like most of the rocks in this part of the State, slightly north-east by south-west. The regularity of the slates has been disturbed by a body of rock thrown up, through which is a micaceous iron pyrites. The decomposition and oxydization of this pyrite has formed the deposits at Katahdin. For many years the furnace was run wholly upon ores which were simply the precipitates of oxide of iron held in solution by the waters of mineral springs that came up through the pyrites and deposited the iron on the sides of the mountain. The ore is all found on the sides and summit of an elevation that is from 200 to 400 feet above the level of the river. When the surface deposits became exhausted, it was found that extensive deposits existed at various depths below the surface that were the product of oxydation of the ledge *in situ* occurring to the depth of 10 to 30 feet. These are sources of the present supply of the furnace, and seem to be practically inexhaustible.

The beds originally found on the surface were practically free from sulphur, or if it existed, it was as a sulphate which was readily driven off by roasting the ore in heaps on the ground. But the beds formed *in situ* were found to contain from 2 to 4 per cent. of sulphur, largely as sulphide, which could only be driven off by intense heat in presence of abundance of air.

This is now being successfully accomplished, and the resulting iron is of superior strength and quality.

Below will be found partial analyses of the ores and pig-iron:

KATAHDIN IRON WORKS.

	Old bed or surface ore.		*New bed or ledge ore.*	
Metallic iron,	51.76	53.81	47.76	57.34
Sulphur,	.69	1.24	3.90	1.24
Phosphorus,	.09	.07	.04	.05

Katahdin pig-iron.	*No. 2.*
Iron,	94.76
Graphitic carbon,	2.84
Combined carbon,	.60
Silicon,	.75
Sulphur,	.049
Phosphorus,	.054
Manganese,	.09

There is an important development of iron ore in Aroostook county, in the vicinity of Aroostook river, in townships Nos. 12 and 13, in ranges 3 and 4.

The formation is composed of silurian slates and limestones interstratified—the whole having been tilted up so that they stand nearly vertical, with the strike north-east and south-west.

The ore occurs as a slaty red hematite in regular veins between the slates parallel with their strike.

In some places the veins or formations are of great thickness and enormous extent. At one or two points there is a thickness of 10 to 12 feet, while at another point the writer uncovered the rocks and took samples of the iron ore at every 10 feet in width for a total width of 90 feet—the ore analyzing from 42 to 48 per cent. of metallic iron, with from .50 to 1.40 per cent. of phosphorus.

Near by the ore is a vein of limestone.

Below I add analyses of the ore and limestone:

Aroostook ore.	*No. 1.*	*No. 2.*	*No. 3.*
Metallic iron,	36.40	46.77	41.93
Metallic manganese,	7.4	3.20	2.72
Phosphorus,	1.09	.61	.94
Siliceous matter,	—	19.20	26.07
Sulphur,	None.	None.	None.

Limestone.	
Carbonate of lime,	90.63
Carbonate of magnesia,	1.51
Siliceous matter,	6.28
Oxide of iron and alumina,	1.12

The Microscopic Structure of Car-Wheel Iron.

By F. LYNWOOD GARRISON, F. G. S.

[From the transaction of the American Institute of Mining Engineers, 1886.]

The study of the microscopic structure of the iron of car-wheels, which it is the aim of this paper to describe, was made at the suggestion of Dr. Dudley, whose paper upon the constitution of cast irons,* and should be read in connection. Although the two wheels referred to in that paper possess nearly an identical ultimate chemical composition, they show physical properties so widely different as to make one of them nearly worthless for the purpose for which it was cast. Considering the chemical similarity, such a marked difference in strength cannot but be very striking, and goes to show how little reliance can be placed upon chemical analysis alone, if *not properly interpreted.* I say "not properly interpreted," because I believe that very few analyses of iron or steel are thus fairly dealt with. That an analysis may read so much of one thing and so much of another, tells us very little as to the properties of the metal; for these are determined to a large extent by the conditions and relations in which the elements are present. To the unaided eye the difference between the two wheels under consideration is not striking. The inferior one would be described as light gray, and the other as somewhat darker. Upon careful examination of an etched fragment, however, the difference in structure will be found to be very marked, as may be seen in Figs. 1 and 2, (re-produced from photographs.)

It is exceedingly difficult to produce a photograph giving a fair notion of the appearance of the metal under the microscope, so as to give a proper appreciation of what a microscopist would consider a decided difference in structure. I would, therefore, urge any one specially interested in this subject, not to depend upon the photographs of others, but to prepare and etch the specimens himself, and then examine them with a good microscope.

As is well known, iron possesses the property of uniting with a number of elements, forming products which are either highly intimate mixtures of several substances, or else compounds of an indefinite character. Indeed such mixtures may be regarded as alloys, or as Matthiessen puts it, "solidified solutions of one substance in another." Of all the elements commonly associated with iron, carbon, and, possibly, silicon have the peculiar property of being capable of existing in the compound in two distinct conditions, one in an amorphous or combined state, and the other as graphite in mechanical mixture with the iron. From the recent researches of Sir Frederick A. Abel,* Dr. C. B. Dudley, and F. N. Pease, of Altoona, Pa., there seems to be much to strengthen the belief of the existence of carbon in iron in a third and combined form, as a "carbide of iron." This compound is described as a "definite product capable of resisting the oxidizing effect of an agent which exerts a rapid solvent action upon the iron through which this carbide is distributed. It is gray in color, and seems to exist in small granules, affecting the continuity of the metal."†

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* *Vide* JOURNAL, Vol. VII, pages 42-45.

That a compound of carbon and iron exists as such in the metal, is by no means proved; and so far as the writer's researches with the microscope have extended, there seems to be little evidence for or against such a hypothesis. It is a generally accepted belief that, when present in considerable quantity, graphitic carbon has a decided effect in decreasing the strength of cast-iron. Such is certainly the case when a certain limit has been passed; but just what this limit is, it would be difficult to determine. It is very probable, however, that this limit is affected by the amounts of other elements present, and by the conditions under which the metal has been fused and cooled, or treated at a temperature below its melting-point. Thus it is found that hardened steel yields no sensible residue of graphite when dissolved in acids; but if, on the other hand, the same steel be annealed, a very considerable amount of graphitic residue will be obtained. It also seems that a temperature much higher than that of the melting-point of the metal is necessary to produce graphitic iron, and that slow solidification after fusion is the condition most favorable to the separation of the graphite in flakes or laminæ. On the other hand, rapid solidification or chilling favors the retention of the carbon in the combined or amorphous state, and produces a hard white and highly crystalline iron, melting at a temperature considerably lower than gray iron. When the amount of manganese present is relatively large, the separation of graphitic carbon takes place to but barely an appreciable extent, the resulting mass, after fusion and solidification, being highly crystalline, and with fractured surfaces of great brilliancy, whence the name of spiegeleisen.

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* Journal of the Iron and Steel Institute.

† We believe Mr. S. A. Ford (in the JOURNAL, Vol. I, No. 1, page 31) first expressed the opinion that the chilling property of iron was due to a third form of carbon, possibly a silicide of carbon or a compound of carbon, silicon and iron.—ED.

It seems almost certain that there exists no ordinary iron or steel in which *all* the carbon is contained in either one condition or the other, but that it always exists in the two (or three) conditions together, and that upon the relative proportions of these depends, in great degree, the quality of the metal. Thus in cast-iron, if the relative amount of combined carbon is large, we have a white iron, but if small, a gray graphitic iron with quite different physical properties. Car-wheels, being made usually from the best grades of pig-iron, can be described as gray iron, the periphery or "tread" alone being white or chilled, and, of course, between the two, a small intermediate zone, containing varying proportions of combined and graphite carbon. In nearly all varieties of gray cast-iron a very marked and characteristic development of the graphitic carbon will be observed when a fragment of the metal has been carefully ground, etched, and microscopically examined. As will be shown below, the existence of the graphite in strong and well-defined lines and plates has a most important bearing upon the strength of the metal.

In Fig. 1, taken from a photograph showing the microscopic structure of the good car-wheel iron, the plates and lines of graphite are very marked, and appear as an irregular mass of small, black lines, which might be likened to a number of small, black worms wriggling throughout the metal. The surrounding mass of metal presents a compact, granular, non-crystalline structure, frequently containing cavities, due to occluded gases or air. It seems impossible to produce castings altogether free from these defects—and it needs not always the microscope, or even a magnifying glass to detect them—but it is doubtful whether their absence would prove of much benefit to the metal for practical purposes. On further examination of Fig. 1, it will be observed that very little of the graphite occurs in isolated irregular patches, as will be seen to be almost always the case in the poorer grades of cast-iron.

In Fig. 2 we have the structure of the poor car-wheel iron. It will be noticed that, although the mass of the metal itself appears to be the same as that of the good wheel, the well-developed and prominent graphite-plates are absent, and are replaced by the graphite in irregular and somewhat isolated patches of comparatively large size, and without any regular grouping. This peculiarity seems general and characteristic of the poorer grades of cast-iron. In nearly all cases metal which shows it is unreliable, lacking the toughness and durability of the better grades.

In Fig. 3 is exhibited a similar structure, being that of a weak and almost valueless pig-iron, containing 4.6 per cent. of carbon, 3.22 per cent. of which is present as graphite in irregular patches, as in Fig. 2. the metal mass itself being compact and granular.

In Fig. 4 is shown the structure of a high-grade hot-blast charcoal pig-iron; the similarity of its structure with that of the good wheel is quite apparent, except that in the latter the graphite-plates are somewhat larger and more prominent.

(By a magnification of 50 diameters it is meant that the above figures represents *spaces* on the surface of the *specimens under examination* having a diameter of $\frac{1}{50}$th of that of the above figures, that is $\frac{1}{50}$th of $2\frac{1}{2}$ inches=$\frac{1}{20}$th of an inch, or about the size of a small bird shot. [•])

These facts indicate that the development and distribution in well-defined lines or plates of the graphitic carbon is at least as important a factor of quality, up to a certain limit, as its total amount. Although it is generally supposed (and undoubtedly with good reason, when the limit has been passed,) that the presence of graphite in quantity renders the metal weak, I have found, in almost all cases where the iron lacked strength that the development of the graphite in plates was only incipient, and that the graphite present existed in irregular patches or clusters of great variety in size and shape.

Of course, this connection between the strength of the metal and the form and distribution of its graphitic contents, even if proved to be an invariable one, need not necessarily represent the only, or the whole, explanation of the case of the two car-wheels now under consideration. Nor is the question answered, as to what cause the difference in graphite distribution is due. Perhaps the following facts may throw some light upon the problem:

Percy* says that the mode of existence of the carbon in iron and steel is, to a certain degree, determined by the conditions under which the solid metal has been heated and cooled at temperatures very much below its melting-point. This point is best illustrated by the annealing of hard steel, and its subsequent treatment with acids, before alluded to. Again, according to Karsten, it seems that even if cast-iron is allowed to cool with the utmost slowness after fusion, it is not then converted into gray iron unless it has been melted at a much higher temperature than was required to bring it to a liquid state.

The following are the analyses of the two wheels as given by Messrs. Dudley and Pease:

	Good Wheel.	*Poor Wheel.*
Total carbon,	3.84 per cent.	3.53 per cent.
Graphite,	3.30 "	2.36 "
Combined carbon,	0.54 "	1.17 "
Silicon,	0.69 "	0.65 "
Phosphorus,	0.43 "	0.52 "
Manganese,	0.13 "	0.12 "
Sulphur,	0.12 "	0.19 "

From these analyses, it will be observed that the poor wheel contains 0.07 per cent. more sulphur than the other. Bell,† in speaking of the influence of sulphur upon cast-iron, observed that, "speaking in general terms, it seems probable that the presence of this element interferes, in some way, with the separation of carbon in the graphitic state, a condition which appears essential to the formation of soft iron."

Although it may not apply in this particular case, it is a well-known fact that silicon, when present in considerable quantity, seems to favor the separation of graphitic carbon, and that the grayest iron is apt to be the richest in that element. As will be seen from Dr. Dudley's paper, the small difference in the amounts of phosphorus present in each wheel, does not, in all probability, affect the result, so that its presence need hardly be considered.

The above citations point to the conditions of fusing and cooling, and to the relative proportions of ingredients other than carbon, as

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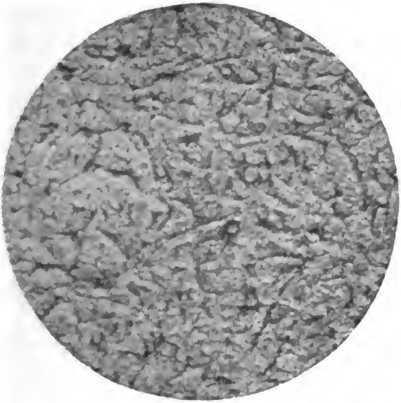
* *Metallurgy of Iron and Steel.*

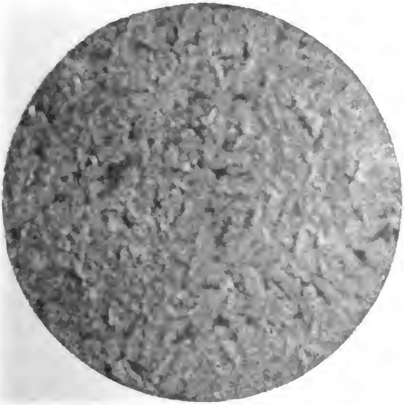
† *Principles of the Manufacture of Iron and Steel*, p. 103.

Fig. 1.



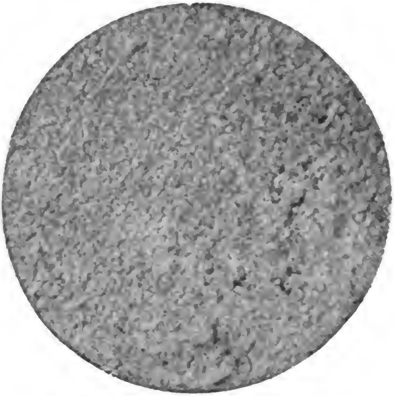
Good Car-wheel Iron, magnified 50 diameters.

Fig. 2.



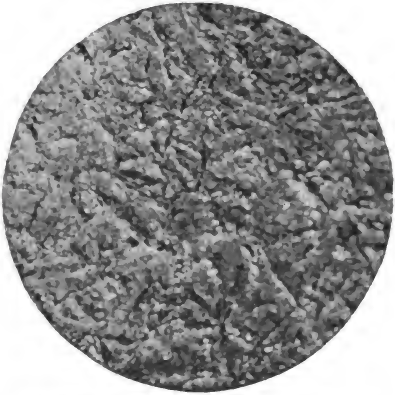
Poor Car-wheel Iron, magnified 50 diameters.

Fig. 3.



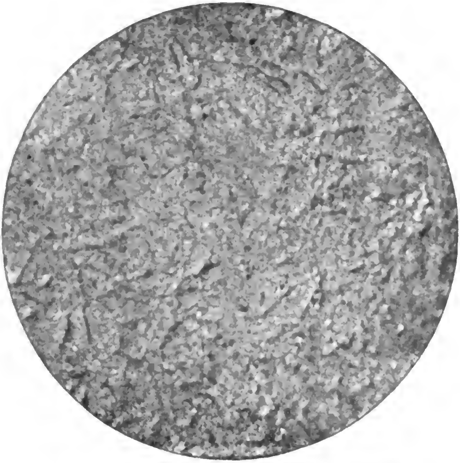
Weak Pig-iron, magnified 50 diameters.

Fig. 4.



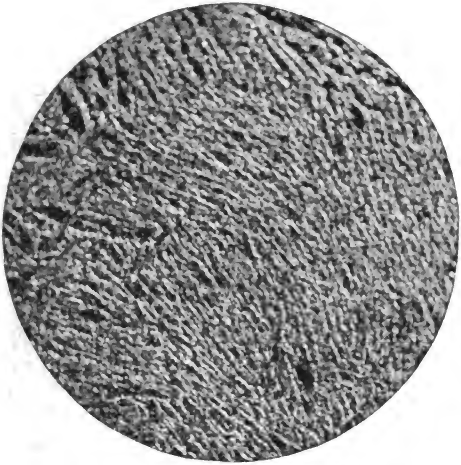
Hot-blast Charcoal-iron, magnified 50 diameters.

FIG. 5.



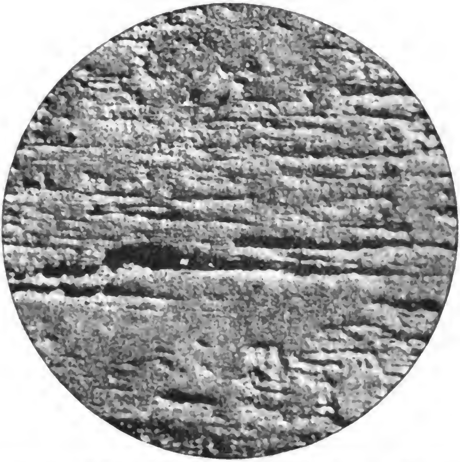
No. 3 Gray Pig-iron, magnified 50 diameters.

FIG. 6.



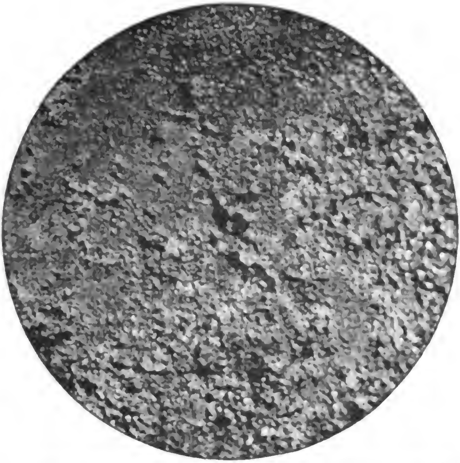
White Pig-iron, magnified 20 diameters.

Fig. 7.



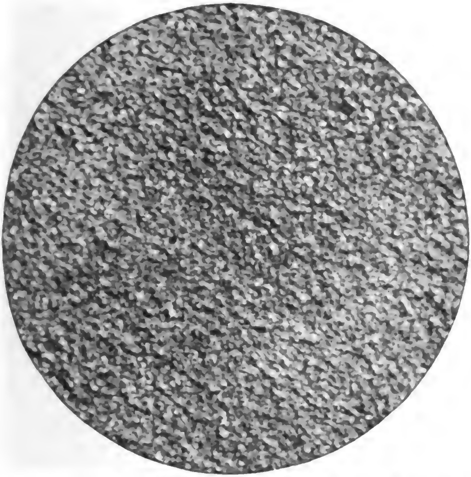
Longitudinal section of Dannemora rolled Bar-iron, magnified 45 diameters.

Fig. 8.



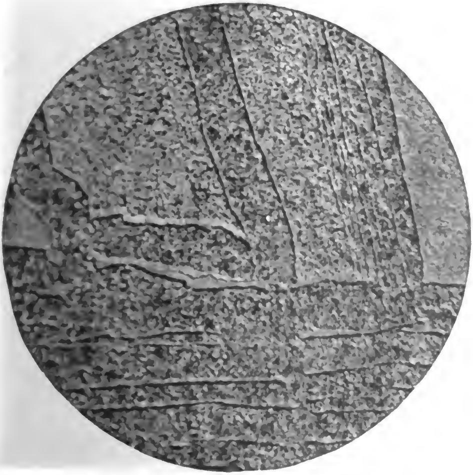
Cross-section of Dannemora rolled Bar-iron, magnified 45 diameters.

FIG. 9.



Dannemora Crucible Tool-steel, magnified 45 diameters.

FIG. 10.



Meteoric Iron, magnified 20 diameters.

controlling the separation of graphite. Dr. T. M. Drown has suggested a very beautiful hypothesis, according to which the amount of graphite separated in any given instance is proportional to the time consumed by the pig-iron in passing through a limited range of temperature, probably near the point of solidification. Adopting this hypothesis, may we not further imagine that the other ingredients, affecting the melting-point of the compound, affect also the limits of this range of temperature; but that, these things being equal, (as they almost are in the case before us,) the conditions of casting and cooling may decide the quality of the product, by determining not merely, as Dr. Drown suggests, the amount, but also the form and distribution of the segregated graphite?

As supplementing the above, we present some of the illustrations from an earlier contribution by Mr Garrison, upon "The Microscopic Structure of Iron and Steel,"—*vide* Transactions American Institute of Mining Engineers, Volume XIV, page 64.

Fig. 5 represents a No. 3 Swedish (Dannemora) Charcoal pig-iron (gray) as it appears under a power of 50 diameters.* The specimen was prepared and etched with the greatest possible care, so that it may be safely taken as a good example of pig-iron, ranging from No. 1 to No. 4, when magnified to that degree. It will be seen to consist of a heterogeneous mixture of metallic iron and long, narrow, black plates of graphite. It does not appear to bear the slightest trace of any crystalline structure. The straight black lines which seem to stand out in relief are the graphite plates. Owing to the comparatively high power used in this case, the slightest inequalities of the etched surface cause an unevenness in the focussing; hence the obscurity of some parts of the plate. By close observation of some parts, however, the structure and the graphite plates can be made out. In many cases of pig and cast-iron the graphite plates seem to group themselves in bunches or lumps. This seems to be more characteristic of cast than of crude pig-iron. It is not unlikely that the second melting and slow cooling enables the graphitic carbon to separate itself more readily in that way.

***Representing a space on the specimen under examination of $\frac{3}{20}$ths of an inch in diameter.** [●]

White pig-iron exhibits a highly crystalline structure, as will be seen in Fig. 6, a sample taken at Dannemora, Sweden. The intensity of the crystallization depends very much upon the degree of chilling. Thus, in a large casting made in a metallic mold, the outer surface, which comes in contact with the mold, will be found to exhibit a high crystalline structure, (such as shown in Fig. 5,) while the inner part, which has cooled slowly, will show very little or perhaps no crystalline structure. This highly crystallized white iron exhibits, even under a high power, only a comparatively small number of graphitic plates. The crystalline structure in some cases is irregular, while in others the crystals are regularly arranged with their long axes normal to the surface of the mold. The plates of graphite will be found to be arranged parallel to the lines of crystallization.

Wrought-iron or mild steel exhibits a fibrous structure, running in the direction in which it has been rolled. Fig. 7 shows the structure of a fine quality of rolled bar-iron. The fiber is distinct and shows numerous furrows and cavities, due to working and the presence of intermingled slag during the rolling. Wrought-iron (not steel) does not show, even under a power of 100 diameters, the slightest trace of crystalline structure. It was held by Percy and other authorities that the fibers were simply drawn-out crystals. I have tried, in numerous instances, to determine if such really was the case, and, although I have examined many longitudinal and cross-sections of various grades, I cannot find that there exists any foundation for such a view.

Fig. 8 shows a cross-section of the same material as Fig. 7. The furrows of Fig. 6 will be seen to be replaced by irregular cavities in the cross-section.

Hard or tool-steel presents a structure entirely different from any of the preceding. It is highly crystalline, uniform in structure, and shows no lines of weakness or any tendency in the crystals to develop themselves in any given direction. Fig. 9 is a high-grade crucible tool-steel magnified 45 diameters.

Fig. 10 shows the structure of meteoric iron, which is quite different from any of the artificial irons or alloys of iron and nickel. The peculiar lines so prominent in the figures are characteristic of meteoric-iron and are commonly known as "Widmannstatten lines." I have not been able to detect these lines in all varieties of meteoric-iron. It seems that if the iron be very impure and contain but a small amount of nickel there is little or no tendency to develop them.

In the discussion which followed the presentation of the "Notes on Constitution of Cast-iron," by Messrs. Dudley and Pease, and Mr. Garrison's paper, the following remarks were made by Mr. S. A. Ford, chemist at the Edgar Thomson Steel Works:

"Dr. Dudley's remarks on certain probable combinations of the metalloids and of the metals in pig-irons and steels recalls very forcibly to my mind experiments which I made some seven or eight years ago on the chilling properties of cold-blast iron and the wearing properties of chilled cast-iron car-wheels. At that time I was chemist of a large car-wheel foundry, and we were endeavoring to discover why one iron would give a good, hard chill, and yet in another iron, although chilling, the chill would be soft and good for nothing; and, furthermore, why one wheel would make a mileage of 10,000 miles, and yet another 100,000 miles. During my experiments I found that two elements played the most important part in the chilling of irons and in the wearing property of chilled wheels, viz, silicon and carbon; consequently, I watched the action of these two elements more closely than any of the others. It was my good fortune to obtain a number of old car-wheels which had records of different mileage. I obtained one which had only made 10,000 miles, and others that had made 40,000, 50,000, 60,000, 70,000, and two that had made over 100,000. The wheel that gave the least service and the wheel that gave the largest amount of service were found to contain almost identically the same amounts of both silicon and carbon.

It was in the chills of these two wheels that I discovered what I am convinced is a combination of silicon with carbon, and this combination of silicon and carbon was greater in the wheel that had made the longest mileage. This fact I also found whenever I tested a wheel that had made good service; this peculiar combination was always present in large quantities. As to how to obtain this silicon, the best way I found was to crush the chilled iron as fine as possible, dissolve in hydrochloric acid of 1.06 specific gravity, and during solution pass a stream of carbonic-acid gas through the flask to prevent oxidation. After boiling for about an hour, the iron having been dissolved, there will be seen in the flask all through the solution small particles which would be taken for flocculent silicon, but of a slightly yellowish color. On filtering this solution and washing this apparent flocculent silicon with dilute hydrochloric acid to get rid of the iron, and then pouring on the filter a hot potash solution of the strength of 1.25 specific gravity, there will now be observed to be a strong effervescence and hydrogen will be given off in large quantities. This apparent silicon will be dissolved and pass through the filter in solution with the potash; in the filter will remain a black mass which resembles black varnish more than anything else I can compare it to. Now these facts were not once obtained, but repeatedly, and I always found that those wheels that had made the largest mileage invariably contained a large amount of this form of silicon, while those wheels that had made a small mileage contained very small quantities of this same silicon.

Further, wishing to use some cheaper irons than the coal-blast charcoal iron, and at the same time irons that would give as good wearing chill as the cold-blast irons, I, through the kindness of Captain Jones, of the Edgar Thomson Steel Works, was allowed to take tests of the heats in the Bessemer converter at different stages of the blow.

My first test was made of the cupola iron as it ran into the converter. I then blew the heat about three and a half minutes, turned down and took a small test. This test on being broken open was found to be fair gray iron. These two irons, the test of the cupola iron and the iron that had been blown three and a half minutes, were the next day melted in crucibles, and we made what is known as "chill tests" of them—that is, a small mold was made with three sides of sand and the fourth side of iron. The test pieces were about 6 inches long and about 2 inches by ½ inch. On breaking these tests the cupola metal was not chilled at all, while the partially Bessemerized metal was found to be chilled for over an inch in depth. On testing this chill I found that it contained this peculiar form of silicon in large quantities. We therefore determined to make car-wheels of this partially Bessemerized metal and see how they would wear. We made the wheels and put them into service. The last that I heard of them was about two years ago, when they had made 250,000 miles, and the report was that they were not worn out yet.

Now, I think from this report of the good service of these wheels that it certainly shows that this insoluble form of silicon plays a very important part in the wearing properties of chilled car-wheels. Another very curious fact, which seems to show that the carbon exists in these chilling irons in some different form than in which it exists in the hot-blast or non-chilling irons, can be proved by dissolving some of the boring of a chilling iron in strong hydrochloric acid, evaporating to dryness and heating until the chloride of iron is all decomposed, then re-dissolving in hydrochloric acid, filtering and washing residue free from iron. Now, if we pour on the filter a hot solution of potash of the same strength as before mentioned, we will obtain a filtrate which will be colored according to the depth of the chill which the iron will take if it be melted and poured against a chilling surface. The deeper the color the greater the chill. By this test I was able to predict, before it was used, how deep a chill an iron would give. I think this certainly proves that silicon and carbon do exist in forms which exert great influence on certain properties of cast-iron, and, if they do in pig-iron, why should they not in steel?

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METAL-WORK OF THE BURMESE.—Both Burmans and Shans are expert blacksmiths, says the *Journal of the Society of Arts*. The latter forge all the *dahs* ("native hatchets") used by themselves and their neighbors in the Hotha Valley; and they annually resort to Bhamo, and the villages in the Kakhyen hills, for the purpose of manufacturing them. Their bellows are of the most primitive stamp, consisting of two segments of bamboo, about four inches in diameter and five feet long, set vertically, forming the cylinders, which are open above and closed below, except by two small bamboo tubes, which converge and meet at the fire. Each piston consists of a bunch of feathers, or other soft substance, which expands and fits tightly in the cylinder while it is forcibly driven down, and collapses to let the air pass as it is drawn up. A boy, perched on a high seat or stand, works the two pistons alternately, by the sticks serving as piston-rods. Charcoal is used for fuel.

The Manufacture of Coke in 1885.

Mr. Joseph D. Weeks, of Pittsburgh, furnishes the following abstract of the statistics of the manufacture of coke in the United States in the year 1885, and comparisons with previous years, in advance of its appearance in the volume of *Mineral Resources of the United States for* 1885. The production in the calendar years 1882 to 1885, by States, was as follows:

STATES AND TERRITORIES.	NET TONS.			
	1882.	1883.	1884.	1885.
Alabama,	152,940	217,531	244,009	301,180
Colorado,	102,105	133,997	115,719	131,960
Georgia,	46,602	67,012	79,268	70,669
Illinois,	11,400	13,400	13,095	10,350
Indiana,	......	...	.....	...
Indian Territory,	2,025	2,573	1,912	3,584
Kansas,	6,080	8,430	7,190	8,050
Kentucky,	4,070	5,025	2,223	2,704
Montana,	....	....	75	175
New Mexico,	1,000	3,905	18,282	17,940
Ohio,	103,722	87,834	62,709	39,416
Pennsylvania,	3,945,034	4,438,464	3,822,128	3,991,805
Tennessee,	187,695	203,691	219,723	218,842
Utah,	250			
Virginia,	....	25,340	63,600	49,139
Washington,	....		400	311
West Virginia,	230,398	257,519	223,472	260,571
Total,	4,793,321	5,464,721	4,873,805	5,106,696

In the Connellsville region of Pennsylvania there were made 3,096,012 tons, or 60.6 per cent., of the coke produced in the United States in 1885.

The statistics of the production and prices of coke, the consumption of coal, and various characteristics of the coke plant for the years 1882 to 1885, are as follows:

	1882.	1883.	1884.	1885.
Number of establishments,	215	231	250	233
Ovens built,	16,356	18,304	19,557	20,116
Ovens building,	712	407	812	432
Coal used, net tons,	7,577,648	8,510,670	7,951,974	8,071,126
Coke produced, net tons,	4,793,321	5,464,721	4,873,805	5,106,696
Total value coke at ovens,	$8,462,167	$8,121,607	$7,242,878	$7,629,118
Value coke at ovens per ton,	$1 77	$1 49	$1 49	$1 49
Yield of coal in coke per cent.	63	64	61	63

The Iron Trade of the United Kingdom.

A very valuable and interesting compilation of data concerning the "iron trade of the United Kingdom compared with that of the other chief iron-making nations," is the latest contribution to the literature of metallurgy, by Sir Lowthian Bell, Bart., F. R. S.

Although this work, a volume of 168 pages, is of a character different from other writings by the author, it shows the same patient research that is noticeable throughout his contributions upon the chemistry of iron production.

From this work we have made the following excerpts, which we believe would particularly interest our readers, and have placed them rather as special items of value than as a connected review, giving American equivalents where English money is mentioned:

GREAT BRITAIN.

"At the present time iron ore is being conveyed by steamers from Bilboa to the Tyne, a distance of fully 1,000 miles, for $1 26 per ton, or about one eighth of a cent per ton per mile. This freight, it is true, leaves little or no profit for the ship, but, on the authority of a large steamship owner, at the present value of provision and coal, a moderate balance in favor of the vessel would remain were the rate $1 44 per ton."

* * * * * *

YEARS.	Total make of pig-iron for the year.	Average make per furnace per week.	FURNACES.		
			In blast.	Out of blast.	Total.
	Gross Tons.	*Gross Tons*			
1806,	258,200	30			
1823,	458,150	34			
1830,	693,900	50			
1839,	1,243,680	64			
1847,	1,999,600	90			
1852,	2,701,000	123			
1855,	3,218,180	103	599	107	706
1860,	3,826,750	126	582	290	872
1865,	4,819,250	146	657	262	919
1870,	5,963,510	173	664	259	923
1875,	6,365,460	194	629	330	959
1880,	7,749,230	263	567	357	924
1884,	7,811,720	261	575	333	908

The foregoing exhibits the make of pig-iron in Great Britain and the number of British blast furnaces in the years named.

Mr. Bell gives the following as the average yield of British domestic ores in the blast-furnace:

North-Eastern district, ...	30	per cent.
Scotland, ...	32.5	"
Wales and Monmouthshire, ...	30	"
Staffordshire, ...	34	"
Cumberland and Lancashire, ...	55	"
Lincolnshire and Northamptonshire, . . .	33	"
Derbyshire, ...	30	"
Shropshire, ...	33	"
Yorkshire, West Riding.	30	"
Sundry places, including Ireland, ...	36	"
Imported ores from foreign countries, . . .	52	"

* * * * *

The quantity of iron lost in reducing cast to wrought-iron is given at 9 per cent., and in remelting and rerolling old rails, 7½ per cent. The limit of phosphorus in Bessemer pig-iron is given as 1 in 1,000.

* * * * *

"British railroads are estimated as requiring 268 tons of pig-iron per mile, and 10 tons of iron are calculated as required per gross register ton in iron hulls of vessels, the machinery and boilers adding 23 per cent. to this amount.

"Owing to the space occupied by machinery, the carrying power, including fuel for engines, of a steamer is about 16 per cent. less than that of a sailing vessel of similar dimensions. On the other hand, the steamship probably makes three and a half times as many voyages as those which are dependent on the wind."

* * * * *

RUSSIA.

"It appears that 97 per cent. of all the iron made in Russia is smelted with charcoal. One representative pleads on behalf of his works that he employs 5,000 men, and pays upwards of $486,500 a year in wages, or about 32 cents per man per day. The conditions of obtaining charcoal are such that even with labor paid at this miserable price, and with the forests for nothing, it would be impossible to make cheap iron. One acre of forest is only capable of producing about 5 cwts. of charcoal. Allowing a furnace of the Middlesbrough type 27,500 tons a year, an estate of 110,000 acres* would be necessary to keep it at work, from all which, along difficult roads, the charcoal would have to be carted."

* * * * *

SPAIN.

"Such iron as is made within the confines of Spain, does not depend on Spanish fossil coal for its production, for, with the exception of Bilboa, where English coke is used, I believe, all is smelted by means of charcoal."

* * * * *

UNITED STATES.

"When the fuel used for smelting iron in America is charcoal, it is usually obtained at no great distance from the mines that supply the ore, because in most places where mining operations are commenced the country is covered with forests.

"The great expense attending the burning of charcoal, and its conveyance to the furnaces, generally renders it more profitable to send the ore—particularly when it is rich, like that of Lake Superior—to localities where pit-coal can be had. Of the 2,352,000 tons of ore raised in 1883, near Marquette, only about 260,000 tons are smelted on the spot, the remainder finding its way to Chicago, Cleveland, Pittsburgh, etc. Such metal as is made near the mines is obtained at a cost of from $7 20 to $8 30 per ton for fuel alone, and then almost the whole of it is sent to the steel works, where pit-coal can be had for converting it into malleable iron, steel, etc."

* * * * *

"Immense and rapid as has been the progress of the iron trade in Great Britain, that in the United States greatly exceeds it. Below is given, in thousands of tons, the make of pig-iron in the two countries for several years, beginning at 1855, to which the American make of iron and steel, as near as I have been able to get them, has been added.

***This is on a basis of a consumption of 2,000 pounds, or 100 bushels of charcoal per ton of pig iron.—ED.**

TABLE (1=1,000).

YEARS.	GR'T BRITAIN.	UNITED STATES.		
	Pig-iron.	Pig-iron.	Malleable iron.	Steel of all kinds.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1855, ...	3,218	700		
1860, ...	3,889	821		
1865, ...	4,819	832		
1867, ...	4,761	1,305	930	
1870, ...	5,963	1,665	1,152	55
1875, ...	6,365	2,024	1,428	389
1880, ...	7,749	3,835	2,083	1,157
1881, ...	8,144	4,144	2,360	1,588
1882, ...	8,586	4,623	2,226	1,727
1883, ...	8,529	4,595	2,097	1,673
1884, ...	7,811	4,098		

Thus it will be seen that while Great Britain increased its production of pig-iron, between 1855 and 1882, 2.64 times, that of the United States has been augmented 6.6 times."

* * * * *

"Not infrequently considerable quantities of fuel require to be stocked at the American furnaces, and almost invariably this is the case in respect to the ore, which is brought from various places, and from such distances—500 miles or more—that it is impossible to work in the "hand-to-mouth style" which is practiced in the English furnaces on the Tees. An inconvenient mode of disposing of the fuel, iron ore, and limestone may very easily involve an additional cost of six cents on each ton, even more, which of itself may mean twenty-four cents per ton on the produce of the blast-furnace."

* * * * *

"The geographical position of iron ore and fuel in the United States, as at present known, renders it impossible that the iron trade, as carried on in the northern portion of the Union, can ever become one of a largely exporting character so far as pig-iron, rails, and other cheap forms of the metal are concerned. The disadvantage entailed upon the manufacture of iron by the distance at which the minerals lie apart is increased by the expense of sending the produce to a seaport, and, so far as the present time is concerned, by the very high price of labor."

Durability of Resinous Woods.

Dr. Heinrich Mayr, in the *Popular Science Monthly*, remarks that there can be no doubt that the rosin in the wood derived from the different varieties of conifers, or pine trees, is one of the most important factors which determine its quality. This is especially true in the matter of durability and resistance against the influence of weather and the different forms of rot, all of which are now proved to be due to specific fungi. At present timber from American conifers is highly valued in Europe, because of its richness in rosin, although the amount of rosin in wood is not the sole measure of its quality. Until now valuation of the importance of pitch in wood was impossible, because the accurate knowledge of the origin and the distribution of the rosin, as well as of the arrangement of the organs producing it, was wanting.

At Munich, Dr. Mayr made numerous experiments, and the results contain many new points of interest. In the face of the confusion prevailing in the nomenclature it is necessary to state that the botanical names used are those of Carriere in his "Traité des Coniferes," who separates *Abies* and *Picea* as distinct genera. The distribution of the resiniferous ducts is so characteristic within each of these genera as to serve as typical marks for them.

The species of *Abies*, commonly called firs, are characterized by the absence of resiniferous ducts within their woods; it is only in rare cases, as in the *Abies firma*, or Japan fir, that we meet with them. Sometimes we find a cluster of parallel cells, often quite far apart from each other, filled with rosin. These colonies of parallel cells are not to be considered as ducts, but as malformations due to the influence of different causes, like cold and pressure. They are found also in other species of conifers exposed to the same causes, and occasionally attain the size of a man's hand. The rosin is produced only by the parallel cells of the medullary rays in the species *Abies*. Already in the first year's growth the cells are found to contain small drops of rosin. The size of these drops increases with the age of the cells, the amount of amylum or starch in them, decreasing in proportion. Rosin is composed of substances volatile at 100° C., and others which cannot be distilled without decomposition; the latter form the solid residue when rosin or pitch is distilled with water. When the outer or sap-wood (*alburnum*) becomes dry or heart-wood (*duramen*), in which form it is that known commercially as "wood," the cells are found to contain nothing but air, with the rosin coating the inside of the cell walls. Fresh pitch, as it oozes from the bark of the European *Abies pictinata*, contains 63 per cent. of solid residue, and this is also the percentage of solid substances in the pitch of the sap-wood of the genus *Abies*, but pitch from the heart or from the dry inner wood of the tree contains 70 per cent. of solid substances.

During the life of a fir tree, the cells contain 50 per cent. of water, which, when the wood dries, disappears; and the pitch, which at first could not enter into the cell walls, now permeates them, taking the place of the water. The wood of *Abies pectinata*, which in Europe covers thousands of acres in dense, well-cultivated masses, contains the least rosin of any fir cultivated, namely, only $\frac{72}{100}$ per cent. of the perfectly dry sap-wood, while the innermost layers of heart-wood contain 1⅛ per cent. of pitch. It is, therefore, of inferior quality, so far as richness in rosin is concerned. Only the very great heights and diameters which trees of this species rapidly attain make them valuable for cultivation.

The genus *Picea* (spruce) has the sap-wood of the same color as the heart-wood; it contains numerous ducts filled with resinous substances. These ducts run in all directions, the horizontal ones being branched off from those running perpendicularly, and communicating with others lying closer to the bark, running vertically. The inside of the ducts is made up of two kinds of cells, the one having thick walls and the same functions as the parenchymatic cells of medullary rays, the others having thin walls. The latter were formerly considered as mere cells of secretion producing rosin; but there are many reasons which force me to consider them as merismatic cells, remaining without function sometimes for several years, until the sap-wood containing them becomes dry, or heart-wood, when they begin their activity. They now increase in size, expanding like vesicles, and totally obstructing the duct, so as to prevent the rosin from entering the heart-wood by way of the horizontal duct or sinking from a higher to a lower part of the tree. In the amount of rosin contained in the wood the genus *Picea* ranks second among conifers; the species *Picea excelsa*, common in Europe, contains 2.16 per cent. in the sap-wood and 1.6 per cent. in the heart-wood.

Only the heart-wood is fit for building purposes, and will stand the influence of weather; the sap-wood will decay rapidly, but is nevertheless used by unscrupulous builders. A microscopical examination of the resiniferous ducts will show the difference at a glance. During the process of transition of the sap-wood into heart-wood, all these resiniferous ducts become closed by the expansion of the cells surrounding them, a process which can be discerned unmistakably even in the smallest piece of any wood from a conifer; a similar process takes place in the growth of the bark.

Professor Hartig, of Munich, proved by careful experiments that the quality of the wood of all trees increases so long as the yearly growth shows a progressive course year after year. It has been thought that the quality of the wood of conifers is the better the closer the annual rings lie; this is but partly true. The older the tree the closer the annual rings, but the quality of the wood increases only as long as those rings represent an actual progress of growth; when once the annual amount of wood formed begins to diminish year by year, its quality becomes impaired, notwithstanding the rings becomes closer and narrower. The amount of rosin in the wood follows the same law; if we take, therefore, a splinter or a plug from any tree by means of a hollow auger, we can, by a simple calculation, determine whether the tree is still progressing, or already on the decline in growth, quantity of rosin, and value.

In the genus *Pinus* the resinferous canals are of different construction, but agree in general arrangement with those of the genus *Picea;* their size is larger, and they are inclosed by only thin-walled merismatic cells, which, in the course of the transformation of the sap-wood into heart-wood, enlarge and close the canals. The heart-wood of the trees of the genus *Pinus* has a light-brown color, sometimes a little reddish, the coloring being due to a product of the oxidation of tannin, which is found in their cells and their walls. The Scotch pine, (*Pinus silvestris*,) when growing on sandy soil, forms only a very small amount of sap-wood, whereas on gravelly and shallow ground it produces more, but of less valuable quality. Two needles in one sheath characterize this species. The heart-wood of this pine contains 5.7 per cent. of rosin, the sap-wood proportionately less. The sap-wood of this tree is quickly destroyed when the tree is cut; it assumes a dark-blue color and rots, through the agency of the mycelium of a fungus called *Ceratostoma piliferum.*

The white pine, or common American pine, (*Pinus strobus,*) is now also extensively cultivated in Germany, where some forests can be found of trees about 100 years old. Its wood has the lowest specific gravity of all coniferous wood. In spring, on account of the thinness of its bark, the tree is quickly warmed through, and the wood cells formed in the beginning of the spring are thin-walled; at the close of the period of vegetation in summer, the annual rings are finished by a few thick-walled narrow cells, thus giving only little thickness to the hard part of the annual layer. In amount of rosin this pine stands at the head of all conifers, containing 6.9 per cent. The percentage increases up to the age of 100 years, and with it the quality of the wood. It is of little value when young and exposed to moisture. *Pinus cembra,* a native of the Alps and Siberia, forms only small, dense rings every year during the short summers of these regions; the wood, hence, becomes heavier, and, although less resinous, more valuable.

The Yield of Iron Ores.

Iron ores are so liberally distributed throughout the United States, and are of such varied composition and richness that, with the existing transportation facilities, it is possible to produce any grade of metal required; but the relative locations of mines and blast furnaces necessarily control the availabilty of many deposits for practical and economical operation. Since chemistry has been so largely employed in metallurgy, the values of various ores have been based as much upon their composition as regards components other than iron, as upon the proportions of iron which they contain; however, the relative value of ores to a furnace manager are in proportion to the percentage of iron which they contain, the other elements effecting more the details of smelting or the market offered for the product.

Silica, phosphorus, sulphur, manganese, alumina, titanium, copper, etc., all influence furnace operation or the market value of the pig-iron produced, but beyond these the amount of ore required to produce a ton of pig-iron is the prominent feature for the blast-furnace manager.

As an addition to the handy reference data published in the JOURNAL, the following table has been prepared to indicate the comparative values of iron ores containing various percentages of iron without any allowances for losses of metallic iron or gains by other ingredients in the pig-metal :

YIELD OF ORE PER CENT.	Tons of ore required per ton of pig-iron.	Pounds of ore required per ton of iron of 2 240 pounds.	YIELD OF ORE PER CENT.	Tons of ore required per ton of pig-iron.	Pounds of ore required per ton of iron of 2 240 pounds.
20,	5.000	11,200	45,	2.222	4,978
21,	4.762	10,667	46,	2.174	4,870
22,	4.545	10,182	47,	2.128	4,776
23,	4.348	9,739	48,	2.083	4,667
24,	4.167	9,334	49,	2.041	4,571
25,	4.000	8,960	50,	2.000	4,480
26,	3.846	8,615	51,	1.961	4,392
27,	3.704	8,296	52,	1.923	4,308
28,	3.571	8,000	53,	1.887	4,226
29,	3.448	7,724	54,	1.852	4,148
30,	3.333	7,467	55,	1.818	4,073
31,	3.226	7,226	56,	1.786	4,000
32,	3.125	7,000	57,	1.754	3,930
33,	3.030	6,788	57.2,	1.750	3,920
33.33,	3.000	6,720	58,	1.724	3,861
34,	2.941	6,588	59,	1.695	3,796
35,	2.857	6,401	60,	1.667	3,733
36,	2.778	6,222	61,	1.639	3,672
36.6,	2.750	6,160	62,	1.613	3,612
37,	2.703	6,054	63,	1.587	3,556
38,	2.632	5,895	64,	1.562	3,500
39,	2.564	5,744	65,	1.538	3,446
40,	2.500	5,600	66,	1.515	3,390
41,	2.439	5,463	66.6,	1.500	3,360
42,	2.381	5,333	67,	1.492	3,343
43,	2.326	5,209	68,	1.471	3,294
44,	2.275	5,094	69,	1.449	3,246
44.4,	2.250	5,040	70,	1.429	3,200

The columns show, first, the percentages of iron in the ore as determined by analyses or practical test. The yield is made to cover the leanest ores which can possibly be used to advantage, say those carrying 20 per cent. to those which approach the theoretical limit of richness. Second. The tons and decimals of a ton of ore of each per cent. of yield required to produce one ton of pig-iron. Third.

The number of pounds for ore of each per cent. of yield necessary to produce one gross ton (2.240 pounds) of pig-iron; no allowances being made for losses or gains.

A theoretically pure magnetite will yield 72.413 per cent. of iron, and would require 1.381 gross tons, or 3,093 pounds, of ore to produce one ton of pig-iron.

Although the usual ton of pig-iron allows for sand and a weight of from 2,250 to 2,270 pounds (generally 2,268) is counted as one ton. we have given the equivalent for 2,240 pounds in the third column; for the sand, if allowed for, does not come from the ore, and in fact the furnace yield is generally greater than chemical analyses show, by reason of the carbon, silicon, phosphorus, etc., in the pig-metal. But to allow for stock-house waste, evaporation of moisture, etc., we believe the table will be found a safe basis upon which to estimate. In the table fractional percentages are only shown where they represent commercial divisions of tons within the limit of richness of the ores ordinarily employed, thus of a 36.6 per cent. ore, 2¾ tons; or of a 57.2 per cent. ore, 1¾ tons are necessary per ton of pig-iron made. Fractional percentages can, however, be readily reduced to pounds or tons by a proportional allowance between the percentages as given.

◆

THE Hon. C. D. Wright, United States Commissioner of Labor, presents data from thirty-four different sources as to the cost of producing one ton of pig-iron with mineral fuels. Foundry-iron made at nineteen furnaces in Alabama, Indiana, New York, Ohio, Tennessee, Virginia, West Virginia, and Maryland, show that the labor per ton at the furnace ranged from $1.114 to $2.481; materials, $6.92 to $14.773; administration and other expenses, $0.30 to $1.60; total net cost, from $11.49 to $17.254.

In the cost of producing one ton of Bessemer iron, made at six furnaces in Ohio and Pennsylvania, the price of labor ranges from $1.14 to $2.50; material, $13.91 to $15.015; administration and other expenses, $0.44.5 to $2.25; total cost, from $16.55 to $18.40.

Mill iron, made in nine furnaces in Ohio and Pennsylvania, varies in the cost of labor per ton from $1.40 to $2.29; material, $9.12 to $11.97; administration, etc., $0.75 to $2.50, and the total cost from $12.87 to $14.95.

The Age of Trees.

The Prussian Chief Forester declares it to be a fable that there are trees in the German forests which have lived for a thousand years. Even the so-called "historical trees," he says, to which an age of 700 to 800 years is imputed, are nothing but "hollows surrounded with bark, vegetating only as ruins." No tree can reach so great an age in Central Europe and remain healthy. He has been at the pains to make inquiries at all the German, Austrian, and Russian forest academies; and, comparing their reports with his own long researches, he has compiled a table of the comparative ages of the different sorts of trees in Central Europe. The highest age is attained by the pine; but after it has reached the limit of sound life it declines more rapidly than any of the leaf trees, which continue vegetation long after they have begun to decay. The oldest pine tree, judging by its annual rings, reaches an age of 570 years. The next in age, the white fir of the Bohmerwald, is 429 years old. The larch, in Bavaria, was at its oldest in 274 years. The oldest sound oak, which is at Ascheffenburg, is 410 years of age. The oldest red beech, also at Aschaffenburg, is 245. The highest point of a healthy age with other leaf trees is as follows: The mountain maple, in Bavaria, 224 years; the birch, 160 to 200 years, in Finland; the ash, 170 years, in Silesia; the elm, 130 years, in Silesia; the aspen tree, 219 years. The most frequent among the so-called "historical trees" in Germany are lime trees, (linden.) The renowned linden of Neustadt-on-the-Kocher, in Wurtemburg, is known by the local chronicle to have had its branches supported by 67 strong staves in the year 1448, so that it must even then have been a venerable tree. It has now seven horizontal branches, which are supported at from 5 to 7 feet from the ground by stone columns. It is reputed to be over 700 years old, but it can hardly be said to be alive; it is quite hollow, and is supported by internal as well as external masonry.

◆

A METAL that expands in cooling is made of lead, nine parts: antimony, two parts; bismuth, one part, and can be used to fill small holes and defects in iron castings.

B. PLATZ, of Dinsburg, Nochfeld, Germany, has examined pig-iron largely used in Germany for mill purposes, called steel pig, which is in reality a low grade spiegeleisen, carrying from 5 to 7 per cent. of manganese. Such pig frequently shows cavities filled with fine scaly crystals, the composition of which differs considerably from that of the pig proper. The following analyses illustrate this:

	Crystals.	*Pig-iron.*
I.		
Silicon,	0.260	0.395
Phosphorus,	0.171	0.525
Manganese,	6.570	6.120
Carbon,	4.808	4.391
II.		
Silicon,	0.229	0 521
Phosphorus,	0.378	0.591
Manganese,	6.970	6.008
Carbon,	4.768	4.376
III.		
Silicon,	0.101	0.313
Phosphorus,	0.272	0.561
Manganese,	6 380	5.872
Carbon,	4.627	4.283

As will be observed, all those samples indicate liquation phenomena, the crystals being lower in silicon and phosphorus an higher in manganese and carbon than the pig-iron. There was a striking difference, too, in the behavior of the two varieties in dissolving with hydrochloric acid.

◆

IT is claimed for a late invention that, while by the old method of molding, casting, dressing, and boring the car-wheels, the average product of three men per day of twelve hours is eighteen wheels, with the new process the same number of men can turn out one perfect wheel every minute, or 720 wheels per day. The principal feature seems to be the substitution of a steel core for one of sand in casting the wheel. Getting this core out of the wheel after it is cast is accomplished by a center key, which falls out upon a single stroke of the hammer and lets the steel core drop out, leaving the hole in the wheel perfectly true, and ready to be put upon the axle without any dressing or boring. We give the figures as presented in exchanges, but consider the promises need verification.

CORK appears to be a solitary exception to the law that in solid substances no appreciable change of volume results from change of pressure, being eminently capable of cubical compression, both from forces applied in opposite directions and from pressure from all sides, such as arose when the substance was immersed in water and subjected to hydraulic pressure. The cause of this anomalous and valuable property of cork was shown to arise from its peculiar structure, which rendered it in many respects more like a gas than a solid. Cork was composed exclusively of minute closed cells, the walls of which were readily permeated by gases, but were impervious to liquids. The cells were filled with air, which, when pressure was applied, yielded readily, and expanded again when the pressure was removed. The impermeability of the cells to liquids prevented cork from getting water-logged when exposed to such fluids in bottles, and this property, combined with permeability to gases, rendered cork superior to India-rubber in waterproof clothing. The substitution of cork for air in the air vessels of water-raising machinery has been satisfactorily tried. Another application was the storage of a portion of the energy of the recoil of guns, and employing it for the purpose of running them out when ready for firing.—*Ex.*

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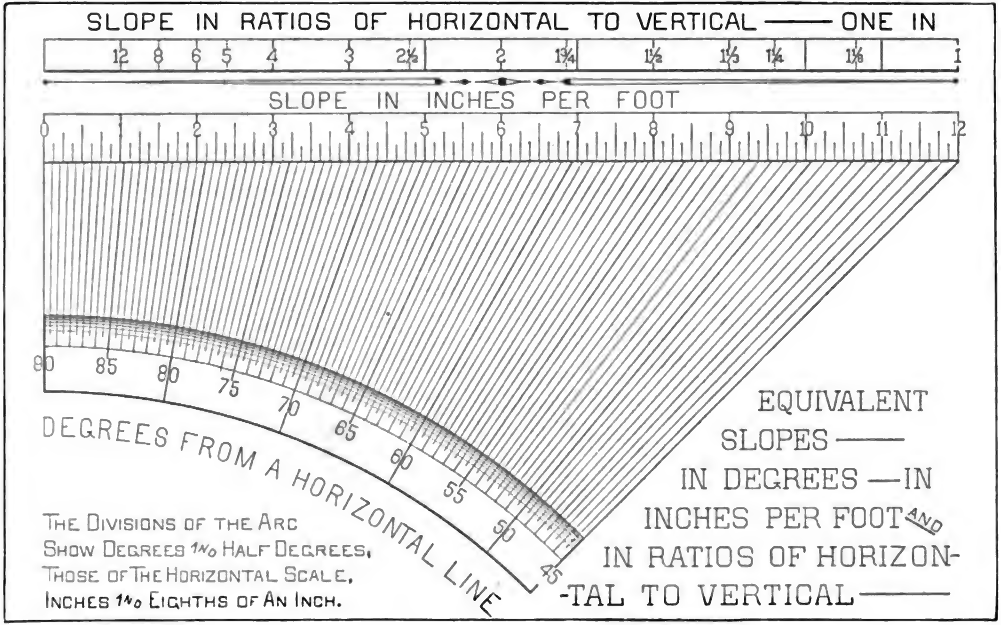
"DOGWOOD possesses many valuable qualities, and it would be well worth growing; it is a beautiful wood, hard, tough, fine-grained, and heavy, its specific gravity being 0.8153. In color it is nearly white, slightly reddish at the heart. It has a beautiful satiny appearance, and takes a high polish readily. The medullary rays are numerous and conspicuous. It is an excellent wood for turning. I have often wondered that it was not used by engravers to a greater extent than it is, although I am told it is already employed for woodcuts quite largely. It seems well adapted for machinery bearings, and I should think it would make excellent wagon hubs. For tools and all manner of handles and mallets it has no superior. There is a tendency toward checking during the process of seasoning, however, especially in large blocks, which needs some care to overlook or prevent. But this is very apt to be the case with all hard, close-grained woods."—*Lumbermen's Gazette.*

OF late the conviction has gradually obtained a place in the minds of many of our people that one leading cause of business depression in this country is the rapid and abnormal increase in our population, caused by unrestricted foreign immigration. This immigration has resulted in an over supply of laborers in all employments; hence, first, competition for employment, and low wages, and, second, strikes and lockouts, and general demoralization in all industrial circles. Unrestricted immigration is also responsible for the presence among us of thousands of idle and vicious foreigners, who have not come here to work for a living but to stir up strife and to commit crime; it is also largely responsible for the attempt to naturalize upon American soil those two most pernicious European foes of social order and national and individual well-being, namely, an unrestrained liquor traffic and a Sabbath devoted to dissipation and amusements. As one consequence of the influences to which we refer there is to-day a revival of interest in one of the Native American issues of 1844 and 1854—a check upon immigration. It does not take the form of opposition to foreigners, *per se*, but of opposition to the immigration of contract laborers, paupers, criminals, socialists, and all foreigners whose antecedents and practices tend to the subversion of the traditions and customs of the country. Many of our foreign-born citizens heartily sympathize with this sentiment.—*Bulletin Iron and Steel Association.*

* * *

THE *Deutsche Industrie Zeitung* has lately called attention to the calorific value of different fuels, and has published a table of the comparative power of heating possessed by various woods, one part of white beechwood being taken as the standard. This is estimated to have the same heating power as 0.99 maple, 1.03 red beech, 1.04 oak, 1.13 ash, 1.17 birch, 1.43 pine, 1.45 fir, 1.667 alder, or 1.99 willow. It is further estimated that 119 cubic feet of beechwood, or 53½ cubic feet of superior coal equal, in caloric power, 629 cubic feet of bad peat, 297½ cubic feet of medium peat, and 164 feet of good peat, while 125 cubic feet of pine wood, or 46½ cubic feet of good coal equal the caloric power of 507, 243, and 138 cubic feet of peat in three grades specified. Where not otherwise stated, these figures apply to good qualities.


SLOPE IN RATIOS OF HORIZONTAL TO VERTICAL —— ONE IN
12 8 6 5 4 3 2½ 2 1¾ 1½ 1⅓ 1¼ 1⅛ 1
SLOPE IN INCHES PER FOOT
0 1 2 3 4 5 6 7 8 9 10 11 12
90 85 80 75 70 65 60 55 50 45
DEGREES FROM A HORIZONTAL LINE
EQUIVALENT
SLOPES ——
IN DEGREES — IN
INCHES PER FOOT AND
IN RATIOS OF HORIZON-
-TAL TO VERTICAL ——
THE DIVISIONS OF THE ARC
SHOW DEGREES AND HALF DEGREES,
THOSE OF THE HORIZONTAL SCALE,
INCHES AND EIGHTHS OF AN INCH.

The Slope of Boshes.

The tenacity with which blast furnace constructors or managers hold to a specific tapers or slopes of bushes, and the variation of such slopes which are championed in different sections or enthusiastically indorsed by individuals, makes it evident that all are not correct, even making liberal allowance for contingencies. The older charcoal furnaces had boshes which battered towards the outer walls at the rate of 10 inches horizontally per foot of height, and many newer coke plants have walls tapering less than 2 inches per foot. In one section this taper is rated by the inches gained horizontally, in another by the number of degrees and minutes which the angle formed by the slope of boshes makes with a horizontal line. To a limited extent a method of rating the slope by the proportion of 1 to 4, 1 to 5, etc., is employed—that is, the horizontal batter is ¼, ⅕, etc., the vertical height. We have several times been called upon to furnish friends with the degrees represented by a certain horizontal batter in inches per foot in height, or by a slope of certain proportions, or *vice versa*, and, with a view of assisting others who may desire to compare different methods, the accompanying graphic representation has been prepared.

The radial lines show the true position with the horizontal, and by following any of these lines, the slope is made apparent to the eye, and the angle made by each line may be read in half degrees on the circle scale, or the batter in inches per foot may be seen on the horizontal scale. The scale of ratios also show the approximate proportion of the horizontal to the vertical for each slope. Thus a bosh having a slope of 80° 30′ batters 2 inches horizontally to each foot of vertical height, or at the rate of 1 horizontal to 6 verticals, or a batter of 1 in 2 is equivalent to 6 inches horizontal per foot of vertical height, or to a slope of nearly 63½°.

The graphic representation may also be applied to embankment slopes, chimney tapers, etc. It is hoped that it will prove as a valuable addition to the tables and formulæ heretofore presented in the JOURNAL, and be a ready reference for our readers when they desire to make comparisons of furnace proportions or judge of the relations which various details bear to others.

We shall not attempt to discuss the merits of different bosh slopes nor offer any rules for their determination; that the slope of boshes has a material influence upon the operation of a blast furnace is evident from the experiment made at Chester, New Jersey, with a straight or no bosh furnace. This form was really less of a deviation from the shape of many modern furnaces than the slope of 2 inches per foot, or 80½°, was from the old charcoal batter of 10 inches per foot, or 50¼°. A slope or batter seems essential for the proper delivery of the descending stock to the crucible of a blast furnace, but the degree of such slope is far from being uniform or even adopted within narrow limits. As pointed out in our editorial on "Improvements in Metallurgy," the slopes now approved are not as steep as those adopted several years ago.

* * *

FOREST fires greatly injure the growth of the trees that survive, as will appear upon comparing the annual layers in trees exposed and in those protected, the former being so thin that they can scarcely be distinguished, while the latter are several times as thick.

Another most injurious effect is the burning out of the organic material in the soil, rendering it sterile upon the surface, to the destruction of the finer and more nutritious grasses, and able to produce only the coarser and more deeply rooting species.

The injuries from the unrestrained range of cattle are scarcely less than those from fires, as well from browsing, as from breaking and tramping down. These damages are less apparent in a pine forest, because the leaves are not eaten, but the loss even there is enormous, and constantly runs to ruin.—*Dr. Charles Mohr.*

* * *

THE YORK IRON COMPANY, of Minneapolis, Minnesota, has completed the erection of a charcoal blast-furnace at Black River Falls, Wisconsin. The dimensions of the furnace are 55 feet by 11 feet; it is equipped with two fire-brick hot-blast stoves, each 60 feet by 16 feet, and has a closed top. It will be operated on local red hematite and magnetic ores, and its estimated annual capacity is 16,000 net tons of pig-iron. It has been named Minneapolis Furnace.

The Good Record of the Spring Lake Charcoal Iron Furnace.

[From C. D. Lawton's Report on the Mines and Mineral Interests of Michigan, now in press.]

"This furnace, at Fruitport, in Muskegon county, on the east shore of Lake Michigan, has been, from the time it first went into blast, successful.

The ore used was largely soft hematite—Milwaukee mine and Lake Superior mine ores.

The wood used for coaling was 30 per cent. hemlock and 70 per cent. mixed elm, beech, and sugar-maple.

The stack is 46 feet high, and the diameter of the bosh is 10 feet 8 inches. The limestone for fluxing was from Kelly Island.

The following is a statement of the working of the Fruitport furnace for the year ended December 31, 1885:

Days run,	321
Bushels of charcoal used,	1,444,675
Tons of ore used,	28,684.8
Tons of limestone used for flux,	386.5
Furnace charges run,	57,787
Tons of pig-iron made,	17,217
Bushels of charcoal per ton of iron,	84
Pounds of limestone per ton of iron,	50
Pounds of ore smelted per ton of iron made,	3,732
Average number of gross tons of pig-iron made per day,	53½
Per cent. of yield of ore,	60¼
Per cent. of soft hematite ore used,	70
Per cent. of hard specular ore used,	30
Size of steam cylinder,	20 inches diameter, 4-foot stroke.
Size of wind cylinder,	60 inches diameter, 4-foot stroke.
Average number of revolutions per minute,	27
Average pressure of blast,	3½ lbs.

There are two ovens, one on the Player plan, having 24 upright pipes, each 12 feet high, giving from 850 to 900 degrees temperature of blast. The other oven is small, old style of horseshoe or U pipes, 3½ inches by 6½ inches diameter, and 8 feet high. This gives a temperature the same as the other. The average hot-blast temperature is 875 degrees.

The charcoal is measured, 2,748 cubic inches making a bushel. When made from dry wood, a bushel weighs 20 pounds as an average. The furnace is advantageously situated on Spring Lake, so that the ore vessels unload expeditiously in the stock-house of the furnace. The freight of the ore from Escanaba, put in the stock-house, is but 75 cents a ton. Kelly Island limestone costs, laid down at the furnace, $1 25 a ton. Freight to Chicago on the iron is 75 cents a ton; the same to Cleveland.

The company has 45 charcoal kilns, 20 rectangular and 25 round ones. The former holds 80 or 90 cords of wood, and the latter 60 cords. The wood costs from $1 25 to $1 75 a cord. Wages paid, $1 25, $1 40, $1 50, and $2 a day.

The ore used in 1885 was one quarter Lake Superior mine, No. 1 specular; one half Lake Superior mine hematite; and one quarter Milwaukee mine ore. The ores bought for 1886 are Colby, Lake Angeline, and Cleveland, No. 1, hard ore.

From January 1, 1885, to July 1, 141 days, the furnace made 55 tons of iron a day, average, using an average of 80½ bushels of charcoal per ton. For the week ended April 4, 1885, seven days, the total product was 441 tons, using an average of 68½ bushels of charcoal per ton, the ore yielding 60⅗ per cent. in iron. The product runs up to 68 and even to 73 tons of iron in a day. These statistics I have taken from the books of the company submitted to my inspection."

Mr. J. C. Ford, the manager, is a member of this Association.

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THE Plymouth, Massachusetts, rivet manufacturers use largely Swedish iron, which comes in the form of wire rods. They pay a duty of $\frac{6}{10}$ cent per pound for No. 5 gauge and upward. Rods below No. 5 gauge are not used for rivets, and pay a duty of 45 per cent. *ad valorem.* The rods cost from $65 to $70 per ton of 2,240 pounds. The rods are sometimes bought by the rivet manufacturers and sent by them to the mills to be drawn, and sometimes are bought from the mills after being drawn into wire. Wire rolling or drawing is a special branch of the rolling business, and requires accurate machinery and much skill on the part of the workmen. The Swedish or Norway iron wire costs about twice as much as American wire. The rivet manufacturers all over the country have been in a trade combination which has been in force three years.—*Iron Age.*

Pyrites.

The production, importation, and consumption of pyrites for sulphuric acid manufacture have grown as follows:

	Mined. (*Gross tons.*)	*Imported.* (*Gross tons.*)	*Consumed.* (*Gross tons.*)
1881,		11,927	7,000
1882,	12,000	29,818	28,900
1883,	25,000	35,811	45,000
1884,	35,000	44,250	68,500
1885,	49,000	53,223	100,000

The remainder of pyrites not used is supposed to be in stock at the works and mines.

The amount of crude sulphur imported varied but little from 100,000 long tons in each year from 1881 to 1884. In 1885, it was 96,841 tons, and the amount is likely to diminish as the use of pyrites becomes more general.

The capacity of the pyrites-burning establishments in this country at present, including two new works just starting, is about 450 tons a day; but the works are not run at their full capacity, and it is estimated that they will make about 275,000 tons of acid this year, while those using sulphur will make perhaps 325,000 tons, giving a total make of say 600,000 tons of fifty degrees acid as the production of this country for the current year. The rapidity of the development of this great industry is almost unexampled even in this country, and it promises to continue growing, but only in the use of pyrites.

Two establishments use Canadian copper-bearing pyrites; five use Spanish and domestic pyrites; and fifteen or eighteen use domestic pyrites.

Refining petroleum and the manufacture of fertilizers are the chief uses for sulphuric acid here, while in England, where the production of sulphuric acid is about 1,000,000 tons a year, about 49 per cent. is used in making sulphate of soda for the Le Blanc soda process, 7 per cent. in making sulphate of soda for glass manufacture, 22 per cent. in making fertilizers, and 22 per cent. for all other purposes.

The prices at which sulphuric acid are now selling are unprecedently low, averaging probably not more than $10 50 and $11 a ton at the works for 50 degrees acid, and some works in Baltimore have been selling, it is said, below $9 a ton. Foreign pyrites are worth, delivered duty paid, about ten cents per unit of sulphur. Our domestic pyrites, especially those from the Arminius mines in Virginia, being purer than any of the foreign ores, command a higher price.—*Engineering and Mining Journal.*

ON the 8th of May, 1686, Sir Isaac Newton transmitted to the world that grand volume known as the Principia; the foundation upon which has been built those marvelous discoveries of physical science that render the two centuries illustrious in the history of man's intellectual and material progress. * * *

When Sir Isaac Newton wrote upon the title page of his great work the simple inscription: "The mathematical principles of natural philosophy," he marked the period of the renaissance of science, and every conclusion that he reaches in his investigations is an example of the method or methods which have done so much to systematize or rationalize modern science. * * *

We believe that by a revival of interest in the Newtonian methods of philosophical inquiry, the intellectual growth of the world will be facilitated and placed upon a more substantial basis.

* * * * *

In whatever manner this great work shall be accomplished, let us not lose sight of the true and only reason for all philosophy and education, the study of the will of the Creator; the search for His rules in order that we may obey; the sum and essence of all philosophy and inquiry.

VERPLANCK COLVIN.

IN the forests of the central Oural district of Russia, wood grows to maturity in about sixty years. The forest is, therefore, mapped out in sixty districts, one of which is cleared each year, while the other fifty-nine are replacing the demand by their regular growth. In fact, eighty years are allowed for regrowth—while the annual consumption is enough to make 8,000 tons of iron—a rate of produce thus rendered possible forever.—*London St. James Gazette.*

THE *American Manufacturer*, which for years has been the recognized iron trade paper of Pittsburgh, is to be complimented upon securing the services of so able an editor as Mr. Joseph D. Weeks to conduct it. The extended journalistic experience of Mr. Weeks, and his studies of special problems for the Government, has eminently fitted him for instilling new life into the *American Manufacturer and Iron World*, and his friends will unite in wishing him unqualified success in his venture. There is no excuse in any one interested in iron metallurgy being ignorant of the progress of the present time, with such publications as the *Iron Age*, and *Engineering and Mining Journal*, of New Yerk; *Bulletin of the Iron and Steel Association*, and our more modest JOURNAL in Philadelphia; *Iron Trade Review*, in Cleveland; *American Manufacturer and Iron World*, in Pittsburgh; *Age of Steel*, in St. Louis; *Tradesman*, in Chattanooga; *The Virginias*, in Staunton, etc. In addition to these we have the *Journal of the British Iron and Steel Institute*, *Proceedings of the American Institute of Mining Engineers*, and of the *American Society of Mechanical Engineers*, and other kindred organizations, to keep any one desiring to investigate well posted and fully abreast of the times.

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A VERY erroneous impression prevails that basic pig can be made anywhere, out of ores that are too high in phosphorus for the acid process. The essential requirements of a basic pig are high phosphorus and low silicon. Without the latter the process is wasteful and expensive. In phosphorus, the minimum requirement is 1.5 per cent. Any percentage above this may be used, but it has been found that a pig-iron with about 2.5 phosphorus gives the most satisfactory result. In Germany, most favorable results are had from the use of a white pig with over 6 per cent. phosphorus and 0.5 silicon.—*Iron Trade Review.*

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THE silver-smelting furnaces of Colorado are estimated as using about seven and a half millions bushels of charcoal annually. The coal is made in meilers and kilns from Piñon, pine balsam, and spruce wood, much of it being dead timber from burned tracts.

G. A. Forsberg's Three-Tuyere Forge Fire.*

By Professor J. v. EHRENSWERTH, *Leoben, Austria.*

About six months since I published in the *Oesterreichische Zeitschrift* an article on G. A. Forsberg's three-tuyere forge fire, called the "Swedish Hearth," and in a preface called attention to the fact that it differed in four points from the ordinary two-hearth forge—the Lancashire hearth—commonly used in Sweden. These points were:

1. The third tuyere in the back.
2. The closed front.
3. The charging hopper, serving also to dry the charcoal.
4. The hollow cast-iron side walls above the fire proper, used to heat the blast.

Numbers 7 and 8 of *Jern Kontorets Annaler*, 1885, contain detailed drawings of such a Forsberg forge which differs from the earlier designs in one additional particular, viz:

5. A bottom vertically adjustible by means of a bottom screw.

Figs. 1, 2, and 3 illustrate such a forge, but it should be noted that the door for closing the upper part of the forge is left out. It is lined with refractory material. In the upper part of this door there is an opening which is used to draw the charge of pig-iron from the preheating section into the fire. The slide of the charcoal hopper is provided with a few holes through which a small quantity of the gas escapes, burns in the hopper, and thus, according to Forsberg's intentions, dries the charcoal, which is charged by drawing the slide. The lower part of the breast is closed by a plate, supplied, in this case, with three rectangular notches, which are used as working holes. This plate is hung in hooks attached to the tie-plates. The hollow side walls, as well as the supply and distributing pipes for the blast, are clearly shown in the drawing. By this method of utilizing the side walls, a blast temperature of 90 to 110 degrees,† Celsius, is attained, that being the heat generally used in forges in Sweden. It may be remarked that the forge is broad in its front part, and that thereby

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***Translated from *Stahl und Eisen*, May, 1886, by C. Kirchkoff, Jr.**

† 190° to 230° Fahrenheit.

Fig 1.

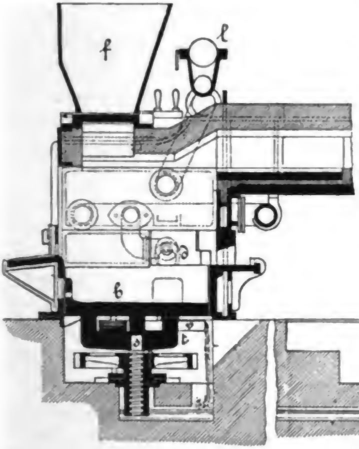


Fig 2.

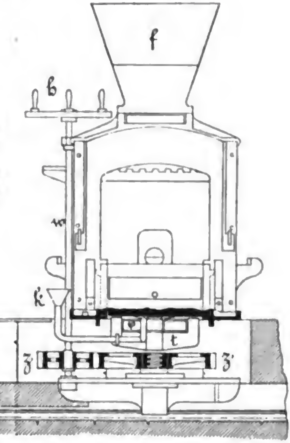
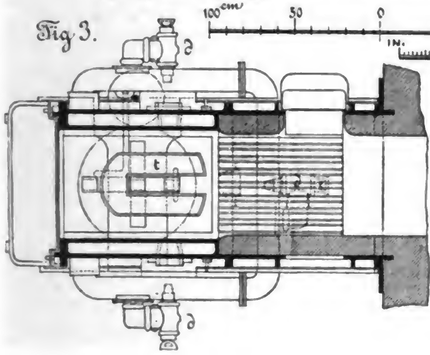


Fig 3.



THREE TUYERE
SWEDISH
FORGE FIRE
WITH
MOVABLE BOTTOM
BY
G.A. FORSBERG

the two opposite side tuyeres appear to be located too far back. This may be caused by the circumstance that the third tuyere in the back is in the way in breaking out the loupe in the ordinary manner, and this must, therefore, be done from the front, necessitating corresponding amount of space in this part of the fire. The bottom, which has play at the four walls, is drawn up in the front, and is provided there with a cinter hole. It rests upon a four-armed carrier, *t*, and is dovetailed into it in the center. This carrier, too, also takes the cooling water trough into which the water is conducted by a pipe provided with a funnel, *k*.

The adjustment of the bottom is done with the hand wheel, *h*, and the cogs, *zz*, the second one acting on the screw of the bottom lift, *s*, journaled in a cross-piece. The screw, *s*, is attached to the bottom carrier, *t*, and, since the latter is in turn connected to the bottom, it is prevented from turning.

The object of this adjustable bottom is to put the fire, at any stage of the process, into such position as is most favorable to it, or, in other words, to aid decarbonization and make the process more uniform. Therefore the bottom is raised at the beginning of the charge, while it occupies its normal position during the breaking up, and the melting for the loupe. It is evident that, other conditions being equal, such a forge fire, with bottom screw, must give the most economical results, and this is proven by the results of the two fires at Hult, which, in a notable manner, eclipse those of all other fires. The fact, that the Hult fires are running steadily proves too that there are none of the mechanical difficulties to speak of which might be thought to attend the system.

Mr. Forsberg's object in designing his forges was, even before he introduced the adjustable bottom:

1. To improve the quality of the product, or render the process less sensitive.

2. To work with greater economy with reference to consumption of materials and labor.

So far as the first point is concerned, the sensitiveness of the forge fire is the result of the close relation existing between temperature and the conduct of the process. The temperature, even in the hottest parts of the fire, is very near that at which the process may still be carried on, while in other parts it is considerably below that limit. This explains, too, why the quality, in the old fires, depends so much upon the qualifications, the industry, and the strength of the workman, in whose power it is to subject all parts of the charge to the same conditions. It explains, too, why what had once been tried and practiced was so clearly adhered to in order to avoid endangering the quality.

Correctly judging the facts, Forsberg aims at a general increase in the temperature and its greater uniformity throughout the whole fire. Contrary to the usual practice, which prevails in a marked degree in Sweden, of moistening the charcoal and watering the fire, he dries it and closes the fire, in order to prevent the radiation of heat. He fills it high with charcoal, as is generally done in Sweden. Although this results in a saving of fuel, and although the temperature must be higher and more uniform as the result of these changes, the principal means toward attaining that end is the use of several tuyeres.

G. A. Forsberg, therefore, uses three, putting the third into the back wall. At Degerfors, however, following out the idea, trials were made with four double fires, in which there are two working sides, located opposite one another. This was introduced in May, 1884. On account of preparations for patents, no details as to working and results have yet been published. But it is proved by the fact that by May, 1885, all of the twelve double fires had been changed to four-tuyere fires, that it must have been successful.

All the reports in regard to the three-tuyere fires agree in pronouncing the quality of the product better and more uniform, and many of them state that it is first-class quality throughout, and, furthermore, that in the new fires less skillful workman can be employed without endangering the quality. The delicate forge process, therefore, has lost much of its sensitiveness.

It is natural that the charge can be increased, and that the production per unit of space and time can be made greater. The result is an improvement in the quality, and a saving of material, time, and wages, which is proven in spite of the comparatively short time during which the three-hearth fires have been running. In order to clearly show this the following table has been compiled, showing the records of the best managed single and double two-tuyere fires, and of three tuyere fires working under the same conditions. So far as possible, fires have been chosen managed by the same forge masters.

RESULTS OF FORGE FIRES IN SWEDEN IN 1884.

A.—Single Fires, with Two Tuyeres.

LOCALITY.	No. of tuyeres.	No. of Workmen.		Charge.			Production in 24 hours. Kilogrammes.	To Produce 100 Kilogrammes.			Waste. Per cent.	Blast.		REMARKS.
		Per fire.	Per shift.	Pig iron.	Scrap.	Total.		Kilogrammes charged.	Cubic metres of charcoal.	Time. Hours.		Pressure, millimetres—quicksilver.	Temperature, degrees—Celsius.	
Domnarfvet, 9 hearths,*	2	4	2	120 110	.	120 110	2,316	114.6	0.376	1.037	12.78			
Ludwigawerk, 2 hearths,*	2	6	3		.		1,914	113.7	0.494	1.230	12.19			
Amot, 3 hearths,*	2	4	2	114 114		114 114	2,101	113.6	0.521	1.143	12.04			
Average,		.						113.9		1.137	12.33			
A number of other works,	2		2-3			98 to 149	1,733 to 2,609	115 to 120	0.475 to 0.578	0.983 to 1.364	13.1 to 16.7			

B.—Double Fires, with Two Tuyeres.

LOCALITY.	No. of tuyeres.	Per fire.	Per shift.	Pig iron.	Scrap.	Total.	Production in 24 hours. Kilogrammes.	Kilogrammes charged.	Cubic metres of charcoal.	Time. Hours.	Waste. Per cent.	Pressure, millimetres—quicksilver.	Temperature, degrees—Celsius.	REMARKS.
Bofors,*	2	6	3	150	.	150	2,600	118.5	0.383	0.914	15.67	. . .	. . .	First quality wire iron.
Bjorkborn,*	2	6	3	150	. .	150	2,533	117.4	0.356	0.947	14.88	.	.	Not first quality wire iron.
Brattford,	2	. .	3	140	.	140	2,530	115.0	0.417	0.940	13.10	96	95	
Degerfors,	2	6	2-3	132	8	140		118.0	0.350	0.903	15.25	108 102	100 80	14 per cent. first quality; 86 per cent. second quality.
Ankarsrum, Forsberg,	2		3?	140		140	2,500? 2,489	117.2	0.469	0.964	14.68			
Average,	. . .	. .	. . .	. .	. . .	. . .	. . .	117.2	. .	0.934	14.89			

* Ranstrom.

RELULTS OF FORGE FIRES IN SWEDEN IN 1884—*Continued.*

C.—Three Tuyere Fires.

LOCALITY.	Number of tuyeres.	NO. OF WORKMEN.		CHARGE.			Production in 24 hours. Kilogrammes.	TO PRODUCE 100 KILOGRAMMES.			Waste. Per cent.	BLAST.		REMARKS.
		Per fire.	Per shift.	Pig iron.	Scrap.	Total.		Kilogrammes charged.	Cubic meters of charcoal.	Time. Hours.		Pressure, millimeties—quicksilver.	Temperature, degrees—Celsius.	
†Hultsbruck, two with bottom screw, ...	3	.	. . . .	149	.	149	2,520 2,623	117.4	0.297	0.95	14.80			
†Skinnaberg, 3**	3	.	. . . .	149	. .	149		114.0	0.388	0.99	12.28	89	110	Much better, more homogeneous product, than in 2-tuyere fires; where the quality was directly noted, stated to be first quality throughout.
†Hellefors, 4***	3	.	. .	140	.	140	2 777 2,415	118 2	0.389	0.97	15.25	"	"	
†Ankarsrum, 1**	3	.	. . .	140	.	140	2,552	118.5	0.392	0 94	15 61	"	"	
Average, ...	.	. .	. . .	.	. . .	.		117.0	. . .	0.96	14.48	"	"	

* Storfors, Bjorbacken, Gustafsstrom, Charlottenberg, Gustafsfors, Fredriksberg, Gravendal, Silkfors.

** One fire running less than one year; toward the close of the year, two more.

*** Running only a very short time; 4 fires at Hellefors only 23¼ days.

† Forsberg.

NOTE.—As one cubic meter is equivalent to 35.317 cubic feet or 22.2 bushels, (2,748 cubic inches,) and one gross ton (2,240 pounds) is equal to 1,016 kilogrammes, the production of each forge and the fuel consumption can be easily determined in American equivalents. In table A we find the average consumption of charcoal per ton of iron made was 104 43 bushels; in table B the consumption was 88.19 bushels, and in table C 82.66 bushels.—ED.

A glance at this table shows that in the cases quoted, the single fires very nearly approach the double fires so far as the consumption of fuel is concerned: while the waste is greater by 2 per cent. in the former than it is with the latter, so that they cannot be given the preference so far as the consumption of materials is concerned. The same is true as regards labor. The double fires, however, yield a daily output nearly 25 per cent. greater and better quality, probably because they are more accessible and admit of completer work.

On the other hand, the table furnishes proof of the undoubted superiority of the three-tuyere fires as compared with the other two so far as consumption of fuel, waste, and labor are concerned, while the output is equal to that of the double fires with two-tuyeres, and in some instances exceeds it. It is clear from it, too, that the position of the fire with bottom screw at Hultsbruck is a leading one since the consumption of charcoal per 100 kilograms of product went down to .297 cubic meters.

The results of the three-tuyere fires deserve all the more attention when it is considered that they have been obtained after running only a short time, and, that in spite of this, they do as well and better than the best two-tuyere fires. It should be noted, however, that, according to Mr. Forsberg's own statement, better results are obtained in the latter when the pig-iron is not suitable; for instance, when it is gray iron with too much silicon, or contains too much manganese. It is likely, however, that adequate changes in the design, and in the method of working would sweep away that distinction.

Mr. Forsberg also suggests a method for further increasing the production of forges by doing away with the melting of the pig-iron in the refining hearth. For this purpose the heating bed for the metal in the flue is to be converted into a melting bed, which is kept warm by the waste flame during the actual firing period, and receives the heat necessary for melting from a gas producer, placed at right angles to the working axis of the hearth. Two hearths, placed back to back, communicate with the same stack, and are served by a producer common to both. The gas being only required during the melting period, the producer is damped during the refining of the metal in the hearth. The gas producer may be worked with inferior fuel, in which case the melting of the pig is done at less cost than in the refining hearth, where charcoal must be used. The melting furnace described is a gas furnace with a flat bed about 20 feet long, and low arch, standing within its own blast-heating apparatus, the latter being a series of short, upright and horizontal pipes, the former also being part of the structural iron work of the furnace. The horizontal pipes are placed below the bed. The gas producer has a stack 10 feet high, shaped somewhat like that of a blast furnace, the bottom being closed by a grate arranged to work upon a central axis. The charging is effected by a gas-tight covered hopper and valves. The gas passes by a syphon up-take and down-come within the same mass of brickwork as a stack, to a chamber forming the ash-pit of the furnace, where it meets the heated air in jets from a square pipe in the roof, a short distance in front of the fire bridge. The producer is worked with waste short ends of deals and planks previously dried at 104° to 150°, the consumption being equivalent to 2.7 bushels of charcoal, supposing the wood to be equal to 63 per cent. of the latter. The loss upon the blooms heated for rolling into merchant iron was 11.5 per cent A further modification of this furnace is provided with two similar gas producers which are worked alternately, the fuel charged wet in one being dried, while in the other it is being converted into gas. For the former purpose the gas delivery passage is closed by a valve at the end of the gas-delivery syphon, and the charging-valve of the hopper is opened while heated air from the hot-blast tubes is passed through the wet wood from below, until hygroscopic water is converted into steam.

THE most extensive brickmaking center in the United States is at Haverstraw, New York, where the works use in a season 42,000 cords of wood for burning brick, at an average cost of $5 00 per cord, in addition to 12,000 tons of coal dust, at $2 00 per ton, and 4,000 tons of coal, at $4 25 per ton.

COMPETENT railway authorities claim that oak ties, at one dollar each, are preferred to iron ties costing three to four dollars each, but when oak ties command more than one dollar the use of iron ties is considered economical.

N. H. Langdon
Port Henry
N.Y.

Vol. 7. 1886. No. 3.

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JOURNAL

OF THE

UNITED STATES ASSOCIATION

OF

Charcoal Iron Workers.

EDITED BY THE SECRETARY,
At No. 152 South Fourth Street, Philadelphia.

ANNUAL SUBSCRITION, $5.00.

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1886.

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JOURNAL

OF THE

UNITED STATES ASSOCIATION

OF

CHARCOAL IRON WORKERS.

Devoted to discussing and illustrating improvements in iron metallurgy, or in the manufacture of charcoal.

It is mailed, post paid, to each MEMBER and ASSOCIATE of the
UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS,
Or can be obtained for an *Annual Subscription of $5 00.*

Edited by JOHN BIRKINBINE, Secretary,
No. 152 South Fourth Street, Philadelphia, Pa.

ARTICLE V. — Constitution of the United States Association of Charcoal Iron Workers.

Any person practically engaged, or interested, by reason of capital invested, in making or using pig-iron or blooms made with charcoal may become a MEMBER of the Association by paying an annual fee of five dollars ($5.) *Provided,* That each iron works represented shall pay not less than ten dollars($10) per annum into the treasury.

Persons not engaged in making or using charcoal pig-iron or blooms may become ASSOCIATES, without the right to vote or hold office, upon the payment of an annual fee of five dollars ($5) each. All fees to be due when the membership is applied for, and thereafter on the first day of October in each year, being in advance.

All communications should be addressed to the Secretary of the Association.

Narrative of the Seventh Annual Meeting of the United States Association of Charcoal Iron Workers.

FIRST DAY.

As announced by circular, the Executive Committee decided, at the request of members of the Philadelphia iron trade, to postpone the annual meeting until November 9, and on the evening of that day an initial business session was held in *Parlor C*, Continental Hotel. It was in this room that the preliminary meeting of the Association was held on June 18, 1879, and in it the organization was perfected. It seemed very appropriate that in meeting where the Association was first formed, the originator of the organization, Mr. J. C. Fuller, should be the President, and that Mr. Coffin, who acted as Secretary *pro tempore* during the formation of the Association, should, with Colonel Wiestling, its first President, be active in the meeting. Other familiar faces made the conference pleasant and social.

THE PRESIDENT'S ADDRESS

in opening the first session referred to the fact that in the room then occupied the organization was first perfected. He gave a history of the conception and earlier development of the Association, of which a *resumé* was given in the JOURNAL, Vol. I, pages 1 to 4. He referred to the work which had been accomplished by the Association and the place in our metallurgical literature which the JOURNAL has won for itself, asking increased individual interest in the organization and cordial support for our publication.

After congratulating the members present that the country was apparently issuing from a season of depression into times of probable prosperity, as indicated by largely augmented demands and slight advance in prices, Mr. Fuller spoke of the increased interest exhibited in charcoal iron, and noted the fact that its merit seems to be more appreciated than for years past. He claimed that the general belief that steel was to take the place of all iron was becoming tempered by more conservatism, and that for good car-wheels, superior boiler-plate, and other special purposes, no superior to charcoal iron, carefully made and honestly manipulated, has been found.

In the brief discussion following the President's address, instances were quoted to indorse the statement concerning the growing appreciation of charcoal iron, among which were the following: Two large Western railway companies, neither of which have charcoal iron works on the line of their road, specify that in their rails a large proportion of charcoal iron must be used. A New England establishment, having made several defective steel boilers, contemplates the use of charcoal iron entirely for this purpose, etc.

LETTERS.

Among the regrets received from members of the Association who were unable to attend the annual meeting, there were some which attracted attention or encouraged discussion from the information or data they presented, as well as for the words of encouragement for a continuation of the work of the organization. That our redears may have the benefit of these letters, we present extracts from some of them.

Our Western and Southern members reported business too good, and the necessity of attending closely to the running of their blast furnaces, so as to keep up with orders, too pressing to permit of their attendance.

Mr. E. W. CRICHTON, superintendent of the Oregon Iron and Steel Company, writing from Oswego, Oregon, says:

"No pig-iron has been manufactured in Oregon since November 1, 1885, when the Oswego furnace was blown out. We then had 3,700 tons of iron on hand, which has all been sold and shipped but 1,300 tons, which, however, now is contracted for early delivery. So we have no pig-iron for sale. The market on the Pacific coast has made close sales, as there has been strong competition between American and Scotch brands of pig-iron, the market ranging from $20 to $22 per ton. Last July the stockholders of our company elected a new president, who intended to complete the new furnace started three years ago and develop the property, but this could not be done because of a cancelled stock subscription of $150,000, which has been a source of litigation for the past two years, and also a law-suit against the owners of a large machine shop in Portland, who merged it with the Oregon Iron and Steel Company in 1883, and then attempted to separate the two concerns. The claim against them is for $225,000 of stock in the Oregon Iron and Steel Company, which they were to take for their plant. This is the reason that we are idle.

When the legal questions are settled, then look for results from Oregon.

During the past summer, there has been a narrow gauge railroad built 6½ miles across our land, extending through a body of fine fir timber that will average 200 cords to the acre. We wish we could take our brothers of the Association along this railroad for about 13 miles that they could see the timber so they would believe this, as we know some of them will doubt it. Although far away, my best wishes are with you, and I hope that the Association will have a pleasant and profitable meeting."

THE TIMBER OF OREGON

was discussed by Mr. John Peebles, of Ohio, who stated that a personal inspection was necessary to convince him of the great yield obtainable from a given area, but, after having visited Oregon, he was able to verify all that had been said by Mr. Crichton in this and former communications. The great height of trees, the absence of limbs near the ground, the straight trunks and regular grain of the wood, not only secured a large number of cords from an acre, but also permitted of obtaining a satisfactory yield of charcoal per cord.

Colonel George B. Wiestling, Pennsylvania, said: "I imagine that the smile, with which the statement '200 cords per acre' is greeted, betrays more of covetousness than gratification.

"To those of us who realize but fifteen per cent. of this magnificient yield, it seems almost incredible, and yet there can be no doubt as to its correctness.

" A believer in the universality of the law of compensation, however, might not have to seek very far, to discover wherein lies our compensation for the absence with us of such timber, for I am informed by one who resided in that section of Oregon, that the rainfall is as great as the trees,—in fact that wet weather is the rule, and clear weather the exception.

"Probably there is a close connection between the two, and if we would have such elegant timber, we might be compelled to accept with it, the excessive rainfall.

"While we congratulate Mr. Crichton on his fine yield of cord wood per acre, we may derive some consolation in our poverty, from the reflection, that probably we have more sunshine than he has."

WEIGHT OF OAK CHARCOAL.

Mr. U. SEELEY, Jr., manager of the Compañia Manufacturera Mexicana de la Montana de ferro, at Durango, Mexico, (the company formed to operate, the Iron Mountain (Cerro de Mercado), described in the JOURNAL,) Vol. III, page 11, writes:

"We are getting our furnace in shape, and have contracted for a large supply of charcoal. We will probably blow in during January next.

I am surprised that the oak charcoal here (Durango) weighs 30 to 32 pounds per bushel of 2,748 cubic inches. Out of one hundred lots of charcoal brought from various places, and made by different parties, the average weight of the oak coal has been 32½ pounds per bushel. What is the usual weight of oak charcoal in different parts of the United States? * * * I truly hope that the Association will keep on its feet, and grow in numbers and in usefulness, and I will be one of fifty members to put it on a sure financial footing."

Colonel George B. Wiestling, Pennsylvania, remarked that: It is exceedingly interesting to contemplate 32½ pounds per bushel as the weight of charcoal, but does it not lack some interest owing to the absence of additional facts throwing some light upon the attendant conditions.

The density of the wood from which charcoal is made, we all know, has very much to do with the weight of the coal.

What kind of trees was the Mexican charcoal made from?

Older, vigorous, healthy, foliferous trees will yield heavier and more solid charcoal, than can be obtained from younger, unhealthy and coniferous trees.

Again, the question is seriously affected by the period of time which elapsed from the drawing of the coal to the weighing of it;

its exposure during this period, and the character of the weather during the exposure. In other words, how much water might it have absorbed before being weighed.

Well charred dry charcoal will contain 12 per cent. of water, and while that made from solid, dense wood will absorb less water, yet light porous charcoal may absorb so much water that it will weigh over one hundred pounds per bushel.

If, in the case in point, the absorption of water was not extraordinary, then I would not know what to attribute the great weight to, excepting to the character and density of the wood from which it was made.

Mr. John Birkinbine, Pennsylvania, stated that he found the woods of Mexico to average greater density than those of the same genera in the United States. The oaks were heavy, and the Mesquit and Huisachic woods were of remarkable density, and so hard as to be worked with difficulty.

The prevailing method of producing charcoal was in small meilers of about 20 cords, and the transportation was by panniers on the backs of burros, or in sacks.

It was, however, presumable that Mr. Seeley, who has had experience in managing charcoal iron works, had made some innovations in the methods pursued, and in fact this was necessary to obtain the amount of charcoal which his works would require. As he knew the value of well-carbonized wood, it is hardly probable that the proportion of brands is excessive, but that the weight of the charcoal is mainly owing to the density of the wood. He expressed the desire that members would furnish the JOURNAL with data as to the weight of oak charcoal from their various works, so that the information asked for by Mr. Seeley would be available for all of the members of the Association.

By request of the President, Mr. John Birkinbine described the Gogebic Iron Range in northern Michigan and Wisconsin, and illustrated by maps its position in relation to the Marquette, Menominee, and Vermillion Iron districts.*

The meeting then adjourned to permit of social intercourse and to allow of ample rest for the excursion planned for the day following.

*** This paper is published in the present issue of the JOURNAL.**

SECOND DAY.

EXCURSION.

Wednesday, November 10, at 8.50, A. M., a special complimentary train, furnished by the courtesy of the Pennsylvania railroad, left the Broad Street station for a trip over a portion of the Philadelphia, Wilmington and Baltimore railroad to inspect some of the numerous industrial establishments.

The first stop was made at Thurlow, a suburb of Chester, Pennsylvania. Here the train was switched to the siding and taken to the Chester Tube Works and to those of the Chester Rolling Company. These works are situated on the Delaware river, fifteen miles below Philadelphia, and have the advantage of transportation by water and rail.

The visitors were received by a committee, composed of Mr. R. Peters, Jr., Mr. George Potts, Mr. T. J. Houston, and Mr. William S. McManus, and conducted through the works.

IN THE CHESTER TUBE WORKS

the instructive process of manufacture was inspected. The manner of welding the tubes was watched with considerable interest, especially by the ladies of the party. Heating the plate and forming it into shape for welding received its share of attention.

After the tubes are welded, cut to length, and tapped, they are taken to the proving shed and submitted to a hydraulic pressure of 700 pounds per square inch. While a party of the visitors were watching this process, the pressure was run up to 1,000 pounds upon a pipe which proved defective, causing a momentary panic, and then considerable merriment at the expense of the unlucky ones that received a baptism. These works have an annual capacity of 18,000 tons of pipes and boiler tubes.

The works are controlled by the Potts Bros. Iron Company of Pottstown, Pa., which the family have operated for forty years, and from which the major portion of iron used at the pipe mill is made. The stock used in the boiler tubes is charcoal pig-iron bloomed in forges controlled by the Potts Bros., and charcoal metal made at the Isabella Furnace, in Chester county, Pa.; belonging to and operated by Col. Joseph D. Potts. This pipe mill does not make the "Butt weld" sizes, confining its pipe production to the "Lap weld" wants of the oil well and oil and gas line purposes, for which special sockets for taper joints are made, and more than ordinary care in making and in the selection of material is required to stand the extraordinary hydraulic pressure, to which this class of pipe has in its uses to be subjected.

THE CHESTER ROLLING MILLS'

mill next received the visitors' attention. These mills were built in 1874–5, and contain eleven double puddling furnaces, five heating furnaces, (two of which are Siemens heating furnaces,) one hammer, and four trains of rolls; product, tank, ship, bridge, and boiler-plate iron; annual capacity, 12,000 net tons.

The open-hearth steel plant was added in 1881–2, and consists of two fifteen-gross-ton Siemens furnaces, having an annual capacity of 22,500 net tons of ingots, worked into plates. As the time of the visit was between heats, the party failed to have an opportunity of witnessing the rolling of heavy plate. The steel plant was not in operation, much to the regret of the visitors.

The blast furnace plant of the company consists of one 70×16 foot stack, equipped with three Whitwell stoves and two compound beam-blowing engines. The fuel used is anthracite and coke. The annual capacity is 40,000 net tons Bessemer pig-iron. Many specimens of the lead obtained by smelting the Spanish iron ores were carried off by the visitors.

Through the courtesy of Mr. Anderson, the manager of the

CHESTER OIL WORKS,

the party was given an opportunity of a hurried visit. These works are a branch of the Tide Water Oil Company, and are situated on the Delaware river a short distance below the rolling mills. Their facilities for receiving, storing, and refining the oils appear to be very complete. The visitors were shown the machinery for and the operation of making the cans used for shipping their products to market. Judging from a cursory examination of the machinery and conveying arrangement for carrying the material and completed cans to the different departments, the saving in manual labor effected must be considerable.

About eleven, A. M., the party boarded the train, and after a pleasant run of thirty-five miles,

THE CHARBON RETORT PLANT,

of the McCullough Iron Company, near North-East, Maryland, and the Mathieu Chemical Plant, were reached, the train stopping at Wilmington to attach the lunch car. These works are situated on the North-East river, and were erected in 1884. Here the party was received by Messrs. J. A. Mathieu and D. Cawley, and escorted through a large stock of cord-wood to the works, where a cordial "Welcome to the United States Association by the McCullough Iron Company" was accorded in the shape of a large canvass draped with flags and placed in a conspicuous position.

The works consist of a 10-retort plant, (Mathieu's patent,) of the McCullough Iron Company, and a chemical plant, of the Wood Extract Company. The charcoal made is used by the McCullough Iron Company in the manufacture of iron at their sixteen-forge fires at North-East, and the by-products collected and prepared for market by the Wood Extract Company.

Much interest was evinced in the different processes and apparatus used to produce the charcoal, alcohol, and acetates. The manner of discharging and charging the retorts was shown and explained.

The charcoal is discharged from the retorts into large conical coolers, then covered and completely luted with clay to cut off all supply of air, and allowed to cool gradually. After it is completely cooled, it is carried to the store-house, where it is screened, elevated to the second story, and loaded on the cars ready for shipment.

The chemical plant consists of the necessary vats, stills and pans for storing, distilling and drying the products obtained from the pyroligneous acid. In the office was a collection of various products: charcoal, pyroligneous acid, wood oil, methylic alcohol, black liquor, acetate of lime, etc., which proved most instructive as showing some of the possibilities from "captured smoke." Samples of these products neatly packed for safe carriage were given the visitors, and Mr. Mathieu desires to send similar samples to any of our readers who were unable to be present.

The arrangement for sawing the wood is in part automatic. After the stick is placed on the conveyor or carriage, it is carried forward, cut into three parts, and dumped into the charging cars. These cars are arranged to charge the retorts through openings in the bottoms protected by swinging doors. Light tracks lead from the saws to the retorts. The charcoal was critically examined by a number of the furnace men present, and their criticism was generally favorable as to quality, etc.

Leaving Charbon works, the party took the cars for the return trip, enjoying *en route* a lunch prepared through the courtesy of the Lobdell Car Wheel Company, McCullough Iron Company, J. A. Mathieu, and others.

At the Wilmington and Northern junction, near the city of Wilmington, Delaware, the train was switched on to the tracks of the Wilmington and Northern railroad and run to the

LOBDELL CAR-WHEEL COMPANY'S

extensive car-wheel and chilled-roll foundries. These works have a capacity of 400 car-wheels per day, and every facility for inspecting the entire plant was afforded the visitors.

At the time of the visit, the cast was being run off; therefore the party had an excellent opportunity of witnessing the process of casting, "shaking out," and cooling, all of which was instructive and interesting.

These foundries are examples of completeness in all details requisite for rapid and easy handling of material, flasks, etc., necessary for this immense output. There was no evidence of crowding, and the work of casting, etc., proceeded quietly and smoothly. The chill-roll foundry unfortunately was not in operation. The machine-shop was next visited, and the wheels and axles in various stages of preparation shown. Much interest was evidenced in the hydraulic process of forcing the wheels on the axles, which requires a pressure of forty tons to press them to place.

The peculiarities of the Lobdell car-wheel foundry were explained by Messrs. George G. Lobdell, P. N. Brennan and W. W. Lobdell, members of the Association. The molten metal and the wheels when cast are handled by overhead trucks and differential blocks the flasks being set in long rows.

After "shaken out" the wheels are placed in long open pits and covered with sand to encourage slow cooling.

Again embarking on the cars, the train was run into Wilmington, and the ship-yard of the

HARLAN & HOLLINGSWORTH COMPANY

visited. After a hurried inspection of the machine-shop, the visitors were taken on board the Vanderbilt steam yacht in course of construction, but, owing to its incomplete condition, little idea could be formed of its general finish, other than its dimensions, lines, and stability.

A monitor, upon which some work was in progress, next received attention; then the dry dock, in which rested the sailing yacht *Priscilla*, one of the participants in the notable races of the year before. The boiler and Smith shops were next visited. The company have several vessels in course of construction, among which was noticed the iron skeleton frame for a Hudson river steamboat and a new fast schooner yacht.

Leaving these works, the party was conducted through the

PUSEY & JONES COMPANY'S WORKS.

Their specialties are sugar and paper-mill machinery and ship-buildings, and their facilities, appear excellent for turning out large quantities of work. The store-house is a model of completeness.

After "doing" these works, it was too late to attempt any further sight-seeing, therefore the projected visit to the "Minquas" rolling-mill of the McCullough Iron Company and Seidel & Hastings' rolling-mill had to be abandoned. The gentlemen serving on the local committee for Wilmington, were Messrs. A. G. Wilson, Washington Hastings, Charles Pusey, and George G. Lobdell.

About 5.20, P. M., the train was boarded for the "home run," where it arrived on schedule time. In fact, the railroad officials complimented the excursionists upon their promptness during the trip; and the visitors voted that they had a pleasant and profitable day in three States.

SECOND SESSION.

After some routine business the evening session was devoted to the reading and discussion of Dr. Hermann Wedding's paper on the "Difference in the Microscopical Structure of Charcoal and Coke Pig Irons," published elsewhere. But in the absence of a stenographic report some features of the discussion are not fully given.

To Mr. Garrison the members were indebted for an opportunity to examine with the microscope some carefully prepared specimens of coke and charcoal pig irons and note their peculiarities, and the lithographic plates were supplied by the generosity of Col. Joseph D. Potts.

The vote of thanks tendered Dr. Wedding and Mr. Garrison were most hearty as well as deserved.

THIRD DAY.

THE FINAL SESSION

was confined to business matters; the report of the committee on finance was first heard and its recommendations cordially endorsed; then the committee on nominations recommended a list of officers, which carried out the suggestions of the finance committee in regard to greater permanence of management. After the committee on courtesies had paid their compliments to those who entertained the Association, the meeting adjourned subject to the call of the executive committee.

In the afternoon visits were made in groups to Philadelphia industries.

THE A. WHITNEY'S SONS CAR-WHEEL FOUNDRY

received general attention as here the method of handling is radically different from that of the Lobdell Car-Wheel Company.

In the large airy casting rooms of the Whitney works the flasks are placed on either side of a tramway, on which are run cars carrying pillar cranes. The ladles of molten metal are brought on trucks to the cranes, which handle the ladles to the moulds. After shaking out, the wheels are run on special trucks to a reversing frame where they are turned over and carried to deep annealing pits warmed by ovens. The visit was timed to see the foundry in operation and all its special features were critically examined, one of these was a "contracting chill," (a model of fine sectional casting,) which consists of a solid rim with about one hundred arms connecting it to a chill plate in one hundred sections, the openings between the arms the chill plate and the outer rim giving ample air space for cooling. The firm claim that this chill insures rotundity and solidity to the wheel tread and flange. Other points of interest were the drop test for determining the strength of wheels, the laboratory and special features of this really elaborate plans.

THE BALDWINS LOCOMOTIVE WORKS

were also visited, but we will attempt no description at this time. One visiting member expressed his opinion of its immensity, when he stated that he walked rapidly for nearly two hours through the works and only then saw a portion of what is to be seen in a manufacturing establishment which produces 500 locomotives annually and whose employés number over 2,000.

The climax of the meeting was the

BANQUET

given to the Association by the Iron Trade of Philadelphia, a compliment which our visiting members well appreciated.

The following gentlemen acted as a local committee for the annual meeting: J. C. Fuller, George G. Lobdell, Abram S. Patterson, John Birkinbine, Joseph L. McDaniel, Henry Whitely, Joseph D. Potts, Jones Wister, Joseph S. Patterson, James S. Whitney, H. T. Townsend, John R. Whitney.

Two or three years ago, some peasants digging near the banks of the Danube, on the Hungarian side, opposite to Belgrade, turned up a most beautiful and finely preserved iron helmet, which is a *chef-d'œuvre* of antique Greek work, of probably three or four centuries before Christ. The helmet is in the shape of a complete head, the face, hair, and beard admirably modeled in *repoussé* or hammered work, finished with the chasing or graving tools in the most exquisite style. The substance of the iron or steel is comparatively light and thin, but by no means flimsy or unsubstantial. In this respect, and also in some others, the helmet is not unlike certain steel Japanese helmets which have been brought to England of late years. These last also have visors in the form of human faces or masks, but they are always of wild, grotesque, and forbidding types. The Belgrade helmet, on the contrary, embodies a perfect ideal of classical Greek beauty.—*Brick and Tile Gazette.*

The Difference in the Microscopical Structure of Charcoal and Coke Pig Irons.

By Dr. HERMANN WEDDING, *Berlin*, *Prussia*,
Honorary member of the United States Association of Charcoal Iron Workers.

[Read at the annual meeting of the Association in Philadelphia, Nov., 1886.]

The differences which are observed between pig-iron produced with charcoal as a fuel and pig-iron made with bituminous coal or coke, generally rest upon variations in chemical composition. These variations depend above all upon the ash and its composition, and particularly upon the sulphur contents of the coke. Furthermore, the density of the carbon in the coke, as compared with that of charcoal leads, in the case of coke furnaces to higher temperatures and greater pressure, by which a more active direct reduction is brought about, and in consequence of which a large quantity of silicon and manganese are carried into the pig-iron. Further influences upon the character of the pig-metal, and especially its uniformity, are brought about by the more careful selection of ores, so far as their chemical composition and their mechanical state is concerned, a more uniform charging and a closer supervision of the furnace in the small charcoal furnaces. It is not surprising that these influences have their effect, but it is surprising that there is such a difference between charcoal and coke pig when their composition is the same, or, in other words, when the percentages of graphite and combined carbon, manganese, silicon, phosphorus, and sulphur are identical or nearly so. In spite of the identical chemical composition, charcoal-iron is better adapted for chilled castings and for malleable castings; wrought-iron, made from coke pig by the same process and with equal care, is not as good as the corresponding product from charcoal pig, so far as ductility and electric conductivity are concerned. It is for this reason that product made from charcoal-iron is preferred in the manufacture of horse-shoe nails and of telegraph wire. Nothing else remains in such cases where chemical analysis furnishes no clue, and fracture, luster, and color give no indications than to fall back upon microscopical structure.

The want of such knowledge has long been felt, but since iron-producers, as a rule, have not the apparatus, nor possess the skill, to undertake the preparation of microscopic slides, a department has been arranged in Berlin at the Royal Experimental Station to carry out such work. The regulations for the use of this department on the part of the general public are given in the journal of the Royal Technical Experimental Station, volume 1886, pages 1 to 39. The slides are prepared as described in a paper before the Iron and Steel Institute in 1885, (see transactions of the Iron and Steel Institute, 1885, volume I, pages 187 to 204, where unfortunately the illustrations have been incorrectly printed. They will be found correctly in *Stahl und Eisen*, 1885, No. 9, plate 26.) The carefully prepared pieces of iron are etched with diluted hydrochloric acid, taking one drop to one liter of distilled water. The etched slides are then colored on a hot iron plate. The colors they thus assume are not in themselves characteristic, but they are always different for the different constituents of the iron, and their differences therefore are characteristic. The following six illustrations show the phenomena always observed when the chemical composition is identical in gray, mottled, and white charcoal, and coke pig. The charcoal-iron was made at Rothehuette in the Hartz mountains, one of the few charcoal plants in Germany, which is famous for furnishing the raw material for chilled castings for armor plate. The pig-iron is produced with charcoal and ore alone without any addition of scrap-iron or any other kind of fuel. As the object was to compare this iron with coke-iron identical in chemical composition, the necessary sample was chosen from the rich collection of the Royal School of Mines of Berlin. It should be noted that it is certain that it was made with coke, but it is impossible to ascertain at what time it was made, so that the conditions cannot be given. The following are the analyses, and it should be observed that it is difficult to find coke pig-iron containing so little manganese and phosphorus as the charcoal-iron.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	GRAY PIG.		MOTTLED.		WHITE.	
	Charcoal Rothehuette.	Coke Mathildenhuette.	Charcoal Rothehuette.	Coke Seraing.	Charcoal Rothehuette.	Coke Terrenoire.
Graphitic carbon,	3.57	3.48	2.33	2.12		
Combined carbon,	0.88	0.54	1.08	0.94	3.28	3.20
Silicon,	1.41	1.50	1.03	0.99	0.19	0.20
Sulphur,	0.01	0.02	Trace.	0.06		0.01
Phosphorus,	0 22	0.45	0.37	0.29	0.70	0.56
Manganese,	0.30	0.35	0.27	0.25	0.30	0.39

The chemical composition may therefore be considered identical in both classes of iron. At any rate it will be found difficult to find a closer approximation.

Figs. No. 1 and 2 exhibit the appearance of etched gray pig-iron. Both charcoal and coke pig-irons show a scaly structure, the scales always showing convex turning of the edges. They are interrupted by sharp streaks of graphite, generally perfectly straight, which, as it were, form the veins of leaves. Between these leafy scales, the back-ground remains of course bordered by concave grooves. The colors brought out by warming shown in the case of No 1 are orange yellow flowers on a silver white ground. In No. 2, gray flowers and nearly black ground.

The difference lies in the following points: In the case of coke pig, the graphite rays course for a considerable distance, sending out branches occasionally, and rarely or never crossing. With charcoal iron, the graphite rays are short and often cross one another in whole bundles. In the case of coke iron, the leafy structure appears plainly and leaves a good deal of black ground. With charcoal pig, it is so close that the back-ground appears only in small streaks, and makes it appear, as though the back-ground were forming the pattern.

Figs. Nos. 3 and 4 exhibit mottled iron made with coke and charcoal.

The leafy structure forms a fine pattern both in the case of coke and charcoal pig-irons, the back-ground being considerably more

Magnified 50 diameters

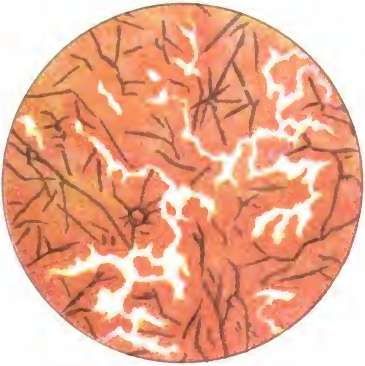

Fig 1 Charcoal Iron Gray

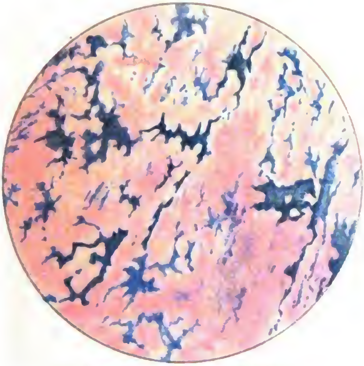

Fig. 3 Charcoal Iron Mottled

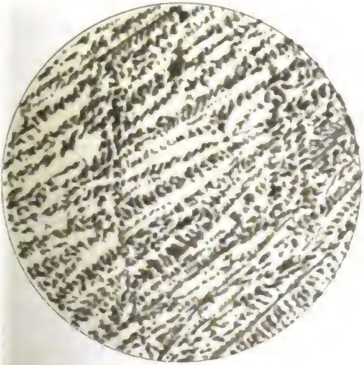

Fig 5 Charcoal Iron White

Magnified 50 diameters

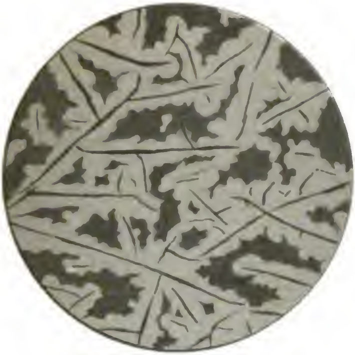

Fig 2 Coke-iron Gray

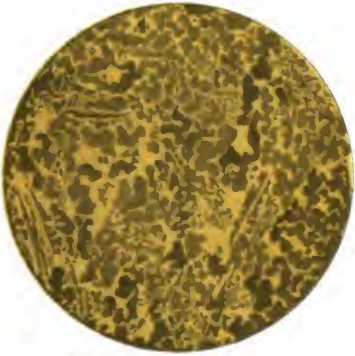

Fig 4 Coke-iron Mottled

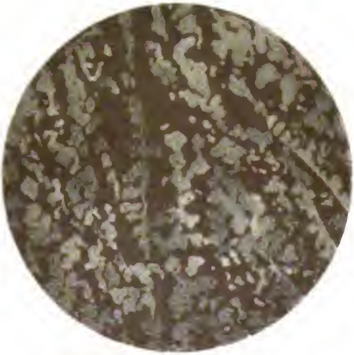

Fig 6 Coke-iron White

cut up than in the case of gray pig. The annealing colors leave the back-ground blue in the case of No. 3, which is the charcoal pig-iron, while it is yellow in No. 4, the coke pig-iron. In the former the pattern is red and orange, and in the latter gray to black. The characteristic difference is that with charcoal iron the leaves come into contact with one another, while in the case of the coke iron they are often separate. It is impossible to observe any arrangement, according to a definite direction, in either of the two classes of iron, although there is a tendency in that direction in the case of coke iron.

Figs. Nos. 5 and 6 show white iron, both coke and charcoal.

In both cases, the leafy structure is almost entirely destroyed, and is separated into groups of streaks, among which two sets, crossing one another at an angle of about 60 degrees, may be noted. The back-ground predominates. In No. 5, the charcoal pig-iron, it appears light yellow, and in No. 6, the coke pig-iron, chocolate brown.

The massive form of the scales in the coke pig-iron is characteristic of it as compared with the more delicate scales of the charcoal pig.

I may note that the same phenomena are observed even when the chemical constitution shows considerable differences. It is only when the manganese contents are larger that quite different forms make their appearance. It is not difficult, when the types illustrated in the above have been carefully watched, to distinguish at a glance charcoal and coke iron under the microscope. It would be premature to draw a conclusion upon the cause of the difference in microscopic structure of charcoal and coke-iron simply on the basis of the few observations made. It is only probable that the fine distribution or mixture of the two kinds of iron in pig is the reason of the character, homogenity, strength, and ductility of charcoal pig. Probably this is due to the slight overheating, as compared to coke pig, which charcoal pig has undergone during the process of its manufacture. I hope that these few results, which are the outcome of many hundreds of observations, may be a guide in future researches. I hope to be able to present to the United States Association of Charcoal Iron Workers further results of my investigations on the difference between wrought-iron produced on the one hand from coke pig-iron, and on the other, from charcoal pig-iron.

THE DISCUSSION

upon Dr. Wedding's paper was opened by the Secretary, who expressed gratification that Dr. Wedding had devoted so much time to the preparation of the paper, and had taken up a subject which seemed to open such possibilities as the microscopic examination of iron and steel offers. He exhibited the original hand-painted illustrations furnished by Dr. Wedding, and stated that the Association was indebted to a member of the Executive Committee for the lithographic reproductions which appear in the JOURNAL. He then read from the British Iron and Steel Institute Transactions extracts from Dr. Wedding's paper referred to in the preceeding pages, so that the Association would have the benefit of the principal features of this publication also.

The following are the extracts read, the paper being entitled "The Properties of Malleable Iron. Deduced from its Microscopic Structure," by Dr. Hermann Wedding.*

Although there can be no doubt that the chemical and physical properties of iron are closely connected, the one cannot be directly deduced from a knowledge of the other. This deduction may, however, be drawn with the greatest certainty in the case of pig or cast iron, which possesses but a low degree of toughness, while the difficulty increases with the decrease in the percentage of carbon, and the increase in tensile strength and ductility. In the case of malleable irons, (steel and iron, ingot and weld steel and iron,) previous experiences have shown that no basis exists on which the connection between chemical and physical properties may be determined with even the slightest degree of certainty.

* * * * * * *

Impossible as it is to say from the chemical composition found by analysis what the physical properties are, it is equally impossible to deduce the chemical composition from the physical properties, for example, from the tensile strength, elongation, and contraction obtained on testing. Frequently, too, even the results of the tests of tensile strength, elongation, and contraction are not sufficient to explain the behavior in use. It has frequently been observed that rails of ingot iron possess the peculiarity of unexpectedly breaking on being suddenly cooled, or on being exposed to a very low temperature; while rails of weld iron, possessing chemically the same composition, and mechanically the same tensile strength, elongation, and contraction. or even when they have given more unfavorable results, remain unaltered. The inconvenience of a sudden fracture of an apparently perfectly sound ingot iron main-shaft of a screw-steamer, has in many cases led to the preference being given to an intrinsically inferior one made of weld iron. * * * * * *

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* *Vide* **Journal of the Iron and Steel Institute, No. 1, 1885, page 187.**

The sections (as per illustrations) are prepared in the following manner: The small test pieces, obtained from the main iron mass by breaking, planing, filing, or crushing, are first ground in a grinding-machine with a coarse emery wheel, and are then evenly and finely ground upon cast-iron plates on which emery is spread. Coarse emery is first employed, and is replaced by finer and finer emery as the grinding proceeds. The pieces of iron are then fastened with a cement of rosin and wax to a thick piece of looking-glass. Water is added in order to guard against the removal of the cement by its becoming hot during the grinding. The polishing is then effected by hand with polishing agents washed as carefully as possible, such as ferric oxide, putty powder, tripoli, &c. The polished section is then etched with very dilute acid: for this purpose platinum chloride, nitric acid, hydrochloric acid, acetic acid, or salicylic acid is employed. A mixture of tincture of galls and acetic acid is also used. After the etching the section is carefully heated, whereupon the portions attacked acquire varying tints, mostly golden-yellow, purple-red, violet, or dark-blue. A subsequent faint gilding has also been employed by Martens. It must be borne in mind that it is not the colors that are characteristic, but their differences. * * * *

Iron, in a pure state, as well as in combination and mixture with the amounts of amorphous carbon, silicon, phosphorus, or sulphur which occur in a wrought-iron of technical value, and, with a small percentage of manganese, crystallizes in the *regular* system. When it is possible for crystals to form freely in cavities, the crystals present an octahedral form resembling a pine tree, with an embodied development of the crystal axes. In the compact iron mass, on the other hand, the individual crystals do not become complete, but press one another, and form *grains* which are for the most part bounded by pentagonal planes.

Evidence of this is afforded by each section of a test piece of iron that has been allowed to cool quietly, and without being disturbed by external pressure, from the fluid or viscous state of aggregation. but is equally obtained in iron produced by an oxidizing process from pig-iron or by re-melting. * * *

Other things being equal, the size of the grains *increases* in proportion to the slowness of cooling; but with the same kind of cooling, with the proportion of carbon up to two per cent., the size of the grains *decreases.* Above this amount, when the percentage of carbon rises or falls, the grains increase in size. *Silicon*, *sulphur*, and small amounts of *manganese*, *titanium*, *chromium*, and *tungsten* favor the *smallness* of the crystals, while *phosphorus increases* their size.

Evidence of this is best afforded by pieces of crucible cast steel containing various amounts of carbon, or containing the same amount of carbon and varying amounts of the other substances mentioned. In this case the microscope is hardly necessary, for even the naked eye can detect the truth. In tungsten steel, containing two per cent. of carbon, an almost amorphous fracture is exhibited.

Manganese in considerable quantities is the only element that changes the regular crystal form of iron containing carbon into a rhombic, or, as the end faces have not with certainty been determined as in right angles, into, at any rate, a form *not* belonging to the regular system. * * * *

As soon as manganese occurs in large quantities, from two per cent. according to my investigations, the regular crystal form of the iron is changed.* This may easily be seen in the case of pig-iron: from granular iron a radiated white iron is obtained; with a larger percentage of manganese, foliated spiegeleisen; and with a still higher percentage of manganese, columnar ferro-manganese is got. Malleable iron with more than two per cent. of manganese occurs only in unsuccessful Bessemer castings. Under the microscope, too, it is difficult to detect the influence of manganese, as the crystalline grains, described later on, appear to acquire, only when the percentage of manganese increases, an elongated columnar form. At all events, these influences may be better detected, as also in the case of pig-iron, with a larger field of vision under a magnifying glass than with the microscope.

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* This statement was combated in the discussion by Mr. Bauermann.—ED.

Each individual grain in malleable iron is *ductile*. The malleability of the entire piece of iron depends upon the ductility of the separate grains.

If *pressure* is exerted on an individual grain in the direction of but *one axis*, as occurs, for example, when a piece of iron is hammered on an anvil, there is formed from the round, or, more correctly speaking, many-sided grain, bounded by pentagonal planes, a plate technically known as "scale" (Schuppe). If, on the other hand, the pressure acts in the direction of *two* axes, either at the same time, as in the case of rolling with a diagonal groove, or at different times, as in the case of hammering an ingot or rolling a bar, turning it round ninety degrees after every passage through the rolls, the grain is converted into a column, which belongs apparently to the tetragonal system, and which is, in practice, termed a "fiber" (Sehne). Fibers are thus elongated grains.

Confirmation of this assertion may be obtained under the microscope with sections cut from rough and worked pieces of iron, partly parallel, partly at right angles to the plane of pressure. The phenomena are, for reasons that are explained below, most distinct in the case of quite soft weld iron rich in slag. In sections parallel to the fibers, the separate columns may be very clearly followed, while in sections at right angles to the fibers no elongation is noticeable. This fact explains why a fracture at right angles to the fibers appears granular to the naked eye. * *

A fiber cannot, however, extend in any possible length without again breaking up when given conditions are brought into play. The *percentage of carbon* has the greatest influence on this phenomenon. If the percentage reaches or exceeds 0.5, the fibers split up into grains with even slight stretching. The same effect is produced also with a low percentage of carbon by a very small amount of *phosphorus*, a large amount of *silicon*, or a not inconsiderable amount of *sulphur*.

Under such circumstances, the fibers on being stretched split up into grains, which must always be smaller than the grains from which they originated.

This phenomenon is better shown under the magnifying-glass than under the microscope, as the field of the latter is not large enough to show several grains at the same time if they are not very minute. The fact that steels rich in carbon, and fine-grained iron, (Feinkorneisen,) form no fibers, is well known in practice. The formation of grains by phosphorus is so characteristic that this property is employed for detecting very small amounts of this element in basic Bessemer iron.

Moreover, this fact shows that from a fibrous iron a coarsely granular iron cannot be formed by any influence, with the exception of elevated temperature. The theory of a conversion of this kind by means of faint concussions must consequently be relegated to the domain of fable. The fracture of a fibrous iron can only exhibit a grain equal to the section of the fibers, or a finer grain when, through concussion, an elongation has been effected.

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In the discussion, Sir Henry Bessemer said that nearly thirty years ago he was anxious to see how far the presence of phosphorus in steel would lend itself to assist in developing crystallization, for he suspected that the large crystals from which his process at that early period was suffering were due to the presence of that deleterious element. Intending to give it every possible chance, he determined to allow the mass to cool as slowly as possible. For that purpose he had a large circular cavity made in the ground, some four feet in depth, lined with bricks. A charcoal fire was kept in it for three or four days, and when the walls of this cavity were heated to a white heat, a large quantity of Bessemer iron, wholly decarburized, was poured into it. The remainder of the cavity was then filled up with hot sand, so that the escape of heat was rendered almost impossible, except by slow percolation. At the end of five or six days, the mass of metal was still very hot, and on taking it out and allowing it to cool, he found that a piece fifteen inches in diameter was readily broken through by a single blow of a large hammer. By taking a portion of the mass and holding it in one hand, and striking it with a two-pound hammer, he could break off showers of loose detached crystals. This showed that the cohesion of the mass had been rendered almost *nil* by the perfect formation of crystals. Their lines of cleavage were so distinct that if any two or three fell in a group they could be detached from one another by a slight blow. Some of the cubes reached nearly the size of common dice—certainly over a quarter of an inch on each face. Their surfaces were beautifully polished and of a silvery whiteness, and could be hammered when cold into discs as large as a fourpenny or a sixpenny piece, thus showing that the metal was malleable, and owed its excessive weakness only to the perfect crystallization which had been encouraged by slow cooling.

Mr. F. LYNWOOD GARRISON, Philadelphia, by invitation, was present with several microscopes, and with numerous prepared specimens of coke and charcoal pig-irons. Prior to the exhibition of these, he spoke as follows:

"Dr. Wedding's conclusions upon the relative structure of gray charcoal pig and gray coke pig seem to be exactly the reverse of my own. He finds that in the coke pig the graphite plates are much larger and much more distinct and prominent than in the charcoal pig. From my own experience, which, however, is not by any means as large as Dr. Wedding's, I would be inclined to say in nearly all cases the graphite plates in the charcoal iron were by far the largest, most prominent, and most easily distinguishable of the two. The data upon which I base this statement was derived from about fifty different samples of gray coke and charcoal pig-iron. It is very true that in some grades of coke pig the graphite is very apparent even to the naked eye, but it will be found upon closer examination that this graphite is *not all* in *plates*, but very largely in *bunches* or *knots*, as I endeavored to show in my paper on car-wheel iron.* As is generally the case with every graphitic irons the metal is weak and often worthless, this latter usually being the case when the graphite is in bunches, knots, or lumps. I cannot account for such a wide difference between Wedding's conclusions and my own, except that possibly my specimens may have been exceptional cases. Dr. Wedding's conclusions are very likely correct, I am also sure my own are, for I quite recently went over my data a second time. With his conclusions on mottled and white irons I agree with him perfectly, except that I have not been able to observe quite as much difference in structure between white charcoal iron and white coke iron as he seems to think there is. I am very much pleased with his method of coloring the sections, and I think its use will lead to very excellent results, but for thoroughly practical work, it will not do near as well as photographing directly through the microscope, as it necessitates the making of drawings and the coloring of same by hand, which is very tedious, and for most purposes a waste of time. I desire to take this opportunity to express my great sympathy for Dr. Wedding in this work, and only regret my results are somewhat at variance with his. In making a comparison between Dr. Wedding's illustrations and my own, much difference will be noticed in the detail and finish of the two. This is due to the fact that the former are drawings made by hand and colored, whilst the latter are photographs taken directly through the microscope, from the negatives of which electro-plates are made for printing, the coloring not being used, as it has to be lithographed. Of course the drawings are much sharper and clearer than the photographs, but they cannot, obviously, be nearly as correct or represent so well what is seen under the microscope."

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* *Vide* JOURNAL, Vol. VII, page 68.

Mr. J. C. **BAYLES**, New York, I have listened with much pleasure to Mr. Garrison's remarks, and find cause for congratulation in the fact that so careful and intelligent a student has entered this most inviting and instructive field of original research. That he has observed phenomena different from those observed and recorded by Dr. Wedding, is not at all surprising. Considering the extent of the field yet unexplored, I find cause for surprise when two observers, working with different materials and under different conditions are able to reach a substantial agreement. There is no reason to assume that Dr. Wedding or Mr. Garrison is mistaken. In my limited work with the microscope I have found confirmation of what Mr. Garrison reports, but I have also found in certain pig-irons what I consider to be a confirmation of the observations of Dr. Wedding. The careful and experienced microscopist will always hesitate to challenge the reputed observations of another, unless he has a chance to examine the same specimens. If satisfied that the observer is intelligent and accurate, he will accept his observations as additions to his limited knowledge of the structure of materials, and use them as aids to safe generalizations.

Microscopy is full of surprises, and will continue to be so until a vast amount of data has been collected, compared, and verified. The first and most important thing to learn is what to look for. Very few of us have yet begun to find out what to look for or what we see when we see it. There is, therefore, serious danger in any form of generalization, and the prudent student will hesitate to venture any conclusions.

It is stating no new truth to say, that, in themselves considered, the results of microscopic study have very little value. For such usefulness as they may possess we are dependent upon the aid of chemical analysis and physical test. When our study of materials shall move along these three parallel lines, each will illuminate the other,and we shall learn a great deal more than we now know. But I would warn the practical ironmakers not to demand immediately practical results of the investigator, and not to become impatient of the seeming worthlessness of isolated data. Every fact established, whether by the lens, by reagents, or by frature, has some value which will ultimately repay the trouble of finding it out. The isolated fact is the unit of knowledge. It is like a dressed stone, of no more value alone than if rough and shapeless; but when we have enough of them, we can build a tower by means of which we may reach a higher and more commanding point of view, with an enlarged horizon. The work of the chemical and physical laboratories is now in good hands, and the pecuniary returns of skillful work are in themselves inducements which attract ambitious young men. Microscopic analysis has yet to establish itself upon a commercial basis. The rewards it presently offers are not measurable in money gains, but I know of no field more inviting to the young man of education and talent, who is seeking an honorable reputation as an original investigator. I congratulate Mr. Garrison upon his choice of a specialty, and shall await with interest his future investigations, feeling sure they will be conducted with conscientious care and with an earnest desire to give his work permanent value.

Col. GEO B. WEISTLING, Pennsylvania, at the risk of exposing my ignorance, and only in the hope of gaining information, do I venture to say a word on this subject.

I supposed that the openness or closeness of the grain in different kinds of pig-iron, and different grades of the same kind, was owing very largely, if not altogether, to the size of the crystals of graphitic carbon in the iron. I do not know what else could affect it, for while, as a rule, more silicon may be expected as an accompaniment with higher graphitic carbon. I fail to see how the silicon could affect the openness of grain.

The results of Dr. Wedding's microscopical examinations as given in his excellent paper, would tend to confirm my assumptions in the matter; but Mr. Garrison's suggestion as to the possible result of his commendable examinations, that charcoal pig presents larger crystals of graphitic carbon than coke pig-iron does, completely upsets my gratuitous acceptances as to the cause of open grained pig-iron.

My acknowledgements are due to Mr. Garrison for correcting me in the use of the expression "crystals of graphitic carbon," as I have profited at least that much by the discussion, for I frankly admit, that I thought graphite did appear as a crystal and hexagonal.

We know that coke pig-iron is more open in the grain than is charcoal pig of the same grade, and if graphitic carbon, under the microscope, appears smaller in the coke than in the charcoal pig of the same grade, then what causes the closer grain in the latter?

Molten pig-iron rapidly cooled shows closer grain and less graphitic carbon than the same molten iron slowly cooled. You will all appreciate that I was sincere in saying that I risked betraying my ignorance by saying aught on the subject. Feeling a deep interest in the matter, I earnestly desire light and I know of no way to get it better than as a first step by confessing my want of it.

I believe that there is a possibility that microscopical examinations of not only different kinds of pig-iron, but of wrought iron and steel, might modify very considerably accepted theories as to combined carbon as well as when in graphitic form.

It would be interesting to know whether the samples of pig-iron examined and compared by Mr. Garrison, contained approximately the same analytically determined quantities of graphitic and combined carbon.

Mr. W. R. DAVENPORT, Pennsylvania, said in our experiments we have been surprised to find that iron which to all appearances was the same in physical properties give widely different results under treatment. Iron may look very unsatisfactory but prove to be first-class in manipulating; and, again, iron may appear well and prove practically worthless for car-wheels. Iron made from the same ores produces very different results, and I can understand why our friend feels diffident in putting before the public any generalization of his experiments. My opinion is that no chemical analysis can determine the value of any iron for car-wheel purposes, and the same with the microscopic examination and measurably so of the physical test.

We rely mainly upon a torsion testing machine which breaks the iron by twisting it, and are satisfied that it is the best method of testing car-wheel irons except as to chilling properties. The iron for car-wheels must have: First. Elasticity combined with great strength. Second. Chilling quality which will give the greatest possible wear under the hardest conditions. Third. Softness in the hub to enable the fitting to be done perfectly.

Mr. C. E. COFFIN, of Maryland, stated that he had made a number of experiments upon cooling pig-iron, by covering it to a greater or less extent with sand, and then submitting it to a tension on a testing machine, and had found that the effect of slow or rapid cooling made little difference in the tensile strength of the metal.

Mr. C. L. HUSTON, Pennsylvania, stated that while he had had no experience with microscopic tests of pig-iron, and, in fact, but little with pig-iron, he had made numerous experiments with wrought iron in bars and in sheets, and the further he carried his investigation, the greater his want of knowledge appeared. After years of examination and experimenting with a testing machine, he considered that it was one of the most, if not the most, reliable method of determining the values of different iron.

Mr. JOHN L. GILL, Philadelphia, described the experiments which he had made in Pittsburgh with a chemical laboratory especially equipped, and with a testing machine built for the purpose of determining the relative values of different irons for the manufacture of car wheels. In the JOURNAL some of these experiments have been noted by Mr. S. A. Ford.* Mr. Gill stated, as the result of his experiments, that he believed that for car wheels as well as for other purposes, the nearer we could approach a combination of iron and carbon only, the better would be the result. (We regret that Mr. Gill could not give us in his own language for the JOURNAL, more in detail, the views he expressed.—ED.)

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THE prevailing sentiment of those who are foremost in advocating forest preservation recognizes that trees like grain grow for man's benefit, which, when ripe, should be cut and put to use. It, however, condemns the useless destruction of forests with the same emphasis that it would the waste of growing grain, and would encourage an equal interest in each, believing that a due proportion of forest is as essential to the public weal as a sufficiency of farm land. It does not seek to reduce the amount of tilled land, but is anxious to protect the farms by maintaining a climatic equilibrium which is only possible where forests are retained in proper proportion. Recognizing the large industrial interests dependent upon the forests, it would, by reforestration of waste lands and preventing needless destruction, make these industries permanent.

It would, while considering the present, look to the future, and, by concert of action, secure legislative enactments to prevent useless waste of our already reduced forests and encourage the propagation of new growths, which, while benefiting the present generation, will maintain a goodly heritage for those who follow us.

—*Forest Leaves.*

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AN exchange remarks that "some timber cutters display marvelous skill in the art of concealing natural defects in timber. Rotten butts, tops, and knots are frequently plugged, and where the work is skillfully done the inspector will have to be wideawake or he will not discover them." We might add that equal skill is noted in many wood-choppers both in cutting and piling the cord wood.

*** *Vide* JOURNAL, vol. I, pages 31-33, and vol. VII, pages 75-77.**

Progress in Iron and Steel Manufacture.

[As all indications point to more prosperous times for the iron industry, the following data concerning the progress made since the close of our late war will be of special interest at the present time. They are excerpts from a very valuable article entitled "*Twenty-one Years of Progress in the Manufacture of Iron and Steel in the United States,*" by Mr. JAMES M. SWANK, *General Manager of the American Iron and Steel Association*, contributed to the special report on the Mineral Resources of the United States, and need no comment.]

As the beginning of the manufacture of Bessemer steel in the United States, in 1864–5, was cotemporaneous with the close of our civil war, after which all the industries of the country were compelled to rely upon a normal demand for their products, the propriety of beginning statistical inquiries with 1865, just twenty-one years ago, is doubly justified.

PRODUCTION *of Leading Articles of Iron and Steel in the United States from* 1865 *to* 1885.

YEARS.	NET TONS OF 2,000 POUNDS.					
	Pig-iron.	Rolled iron, including nail plates, but excluding iron rails.	Iron rails.	Steel rails.	Steel ingots and other steel.	Blooms from pig and scrap iron and iron ore.
1865, . .	931,582	500,048	356,292	. . . . . .	15,262	63,977
1866, . .	1,350,343	595,311	430,778	. . .	18,973	73,555
1867, . .	1,461,626	579,838	459,558	2,550	22,000	78,073
1868, . .	1,603,000	598,286	499,489	7,225	30,000	75,200
1869, . .	1,916,641	642,420	583,936	9,650	35,000	69,500
1870, . .	1,865,000	705,000	586,000	34,000	75,000	62,259
1871, . .	1,911,608	710,000	737,483	38,250	82,000	63,000
1872, . .	2,854,558	941,992	**905,930**	94,070	160,108	58,000
1873, . .	2,868,278	1,076,368	761,062	129,015	222,652	62,564
1874, .	2,689,413	1,110,147	584,469	144,944	241,614	61,670
1875, . .	2,266,581	1,097,867	501,649	290,863	436,575	49,243
1876, . .	2,093,236	1,042,101	467,168	412,461	597,174	44,628
1877, . .	2,314,585	1,144,219	332,540	432,169	637,972	47,300
1878, .	2,577,361	1,232,686	322,890	559,795	819,814	50,045
1879, .	3,070,875	1,627,324	420,160	693,113	1,047,506	62,353
1880, . .	4,295,414	1,838,906	493,762	968,075	1,397,015	74,589
1881, . .	4,641,564	2,155,346	488,581	1,355,519	1,778,912	84,606
1882, . .	**5,178,122**	2,265,957	227,874	**1,460,920**	**1,945,095**	**91,293**
1883, .	5,146,972	**2,283,020**	64,954	1,295,740	1,874,359	74,758
1884, . .	4,589,613	1,931,747	25,560	1,119,291	1,736,985	57,005
1885, . .	4,529,869	1,789,711	14,815	1,079,400	1,917,350	41,700

Maxima in full-faced type.

The leadership of Pennsylvania as the producer of about one half the pig-iron that is yearly made in the United States has long been known, but in the other States and in the Territories there has been less constancy in production. A great shrinkage in the last six years is observable in New England, New York, New Jersey, Maryland, Wisconsin, and Missouri, while there has been a great increase in the same time in Virginia, Alabama, Tennessee, and Illinois. Various causes have contributed to these changes, most prominent among which is the greater cheapness with which the raw materials of manufacture can be brought together in the States which show progress than in those which have fallen behind. The Southern States show an increase in production during the past six years of nearly 52 per cent., while the production of the Middle and Western States has been practically stationary, and that of New England has declined about 60 per cent. In one of the Southern States, Virginia, the increase from 1880 to 1885 was from 29,934 tons to 163,782 tons, or 447 per cent.; in another Southern State, Tennessee, the increase was from 70,873 tons to 161,199 tons, or 127 per cent.; and in another Southern State, Alabama, the increase was from 77,190 tons to 227,438 tons, or 194 per cent. In the Rocky Mountain and Pacific division the manufacture of pig-iron is making slow progress, but it must grow with the lapse of years. The whole number of blast furnaces in the United States at the close of 1885, not including those which had been abandoned or were not likely ever again to be put in blast, was 591, of which 276 were then in blast and 315 were out of blast. The furnaces out of blast were generally the smallest and least favorably situated.

In the last six years, 30 States and one Territory have rolled iron. This branch of our iron industry is even more widely distributed than the manufacture of pig-iron.

Of the 17 States which made cut nails within the last six years, Pennsylvania, as usual, leads. Down to 1883, all the cut nails made in this country were made of iron. In that year we made 18,224 kegs of steel nails; and in 1885 we made 1,823,127 kegs, including a small quantity of combined iron and steel nails. The rapid progress in the manufacture of steel nails in 1884 and 1885 is as notable as that of steel rails in earlier years.

Iron Ore.—We estimated the domestic production of iron ore in 1884 which went into consumption in that year at 7,718,129 gross tons. By the same method of calculation which was then observed, the domestic iron ore which was produced and consumed in 1885 may be estimated at 7,600,000 tons. To ascertain the total quantity of iron ore which was consumed in these two years, the quantity imported in each year must be added to the above figures.

The production of iron ore by all the iron-ore mines of the country cannot be obtained except in census years. The production by the leading mines in the last three years has, however, been carefully ascertained, and the statistics are given below. They embrace more than half the production of the whole country in each of the years mentioned.

PRODUCTION *of iron ore in certain leading districts of the United States in* 1883, 1884, *and* 1885.

DISTRICTS.	GROSS TONS OF 2,240 POUNDS.		
	1883.	1884.	1885.
Marquette Range, of Lake Superior,	1,305,425	1,557,389	1,430,422
Menominee Range, of Lake Superior,	1,047,863	895,634	680,435
Vermillion Lake mines, of Minnesota,	Not opened	62,124	225,484
Gogebic mines, of Michigan,	Not opened	1,022	111,661
Miscellaneous mines, of Lake Superior,	.	1,879	441
Total production of Lake Superior mines,	2,353,288	2,518,048	2,448,443
Missouri,	295,430	233,225	234,162
Cornwall, Pennsylvania,	363,143	412,320	508,864
Chateaugay mines near Lake Champlain,	194,704	214,394	143,278
Other Lake Champlain mines, including the Port Henry and Crown Point mines	305,300	290,500	235,799
New Jersey,	521,416	393,710	330,000
Salisbury District, Connecticut,	35,000	25,000	32,000
Hudson River Ore and Iron Company, New York.	20,000	90,000	55,000
Cranberry mines, North Carolina.	19,377	3,998	17,839
Tennessee Coal, Iron, and Railroad Company's Inman mines,	36,437	70,757	94,319
Total of all the above districts,	4,144,095	4,251,952	4,099,704

Our importation of iron ore in the last seven calendar years has been as follows:

YEARS.	Gross tons.	YEARS.	Gross tons.
1879,	284,141	1883,	490,875
1880,	493,408	1884,	487,820
1881,	782,887	1885,	390,786
1882.	589,655		

Previous to 1879, our imports of iron ore did not exceed 100,000 tons annually. In the present year they will exceed 600,000 tons.

Causes of the Activity of the United States in the Manufacture of Iron and Steel.—In the development of our iron and steel industries, the possession of all the necessary raw materials of manufacture gave opportunity for the employment of the national traits, and the rapid growth of the country in population created an active demand for iron and steel.

More than one half of all the iron and steel that has been produced in this country since 1865 has gone into the construction and equipment of our railroads. We have to-day more miles of railroad than the whole of Europe, and more than two fifths of all the railroad mileage of the world. The greatest activity in the building of railroads in this country has prevailed, however, during the last twenty-one years. At the beginning of 1865, we had about 34,000 miles of railroad in operation; at the present time, we have about 130,000 miles. Another cause that has greatly contributed to the wonderful development of our iron and steel industries during the period under review is the economic and fiscal policy of the National Government in partly, but not sufficiently, checking by customs duties the importation of iron and steel from other countries.

We export only very small quantities of iron and steel, principally in the form of machinery, but we have been large importers of iron and steel in all forms, which we have consumed in addition to the large quantities we have ourselves produced. Our imports of iron and steel during the last fifteen calendar years have been as follows. The quantities of pig, bar, band, plate, and sheet iron, rails, old iron, and tinplates are given for every year mentioned, and for 1882 and succeeding years the quantities of other iron and steel which could not be obtained for preceding years are added:

Years.	Gross tons.	Years.	Gross tons.	Years.	Gross tons.
1871, ...	1,141,933	1876, . . .	204,211	1881, . .	1,180,749
1872, ...	1,183,066	1877, . . .	211,408	1882, . .	1,192,296
1873, ...	640,858	1878, . . .	211,102	1883, . .	694,330
1874, ...	301,647	1879, . .	769,984	1884, . .	654,696
1875, ...	239,712	1880, . .	1,886,019	1885, . . .	578,478

In the following table the quantities and values of pig-iron and iron and steel rails which have been imported during the last thirty-one fiscal years are given:

QUANTITIES *and values of pig-iron and iron and steel rails imported into the United States from* 1855 *to* 1885.

FISCAL YEARS.	PIG-IRON.		IRON AND STEEL RAILS.	
	Gross tons.	Values.	Gross tons.	Values.
1855, ...	98,925	$1,979,463	127,516	$4,903,990
1856, ...	59,012	1,171,055	155,495	6,179,280
1857, ...	51,794	1,001,742	179,305	7,455,596
1858, ...	41,986	739,949	75,745	2,987,576
1859, ...	72,517	1,049,200	69,965	2,274,032
1860, ...	71,498	1,005,865	122,175	3,709,376
1861, ...	74,026	979,916	74,490	2,162,695
1862.	22,247	285,323	8,611	222,967
1863, ...	31,007	435,194	17,088	540,494
1864, ...	102,223	1,288,424	118,714	3,904,017
1865, ...	50,652	806,552	77,518	2,903,828
1866, ...	102,392	1,683,186	78,007	2,806,390
1867, ...	112,042	1,831,465	96,272	3,317,862
1868, ...	112,133	1,778,977	151,097	4,378,162
1869, ...	136,975	2,138,030	237,703	7,305,845
1870, ...	153,283	2,509,280	279,765	9,669,571
1871, ...	178,188	3,106,490	458,055	17,360,297
1872, ...	247,528	5,122,318	531,536	22,056,635
1873, ...	215,495	7,203,769	357,629	19,740,702
1874, ...	92,041	3,288,022	148,918	10,758,435
1875, ...	53,748	1,458,668	42,082	2,932,311
1876, ...	79,455	1,918,547	4,708	321,020
1877, ...	67,922	1,556,415	30	1,464
1878, ...	55,000	1,250,057	11	530
1879, ...	87,576	1,924,128	2,611	70,071
1880, ...	754,657	14,654,227	152,791	4,952,286
1881, ...	417,849	8,766,461	302,294	10,331,768
1882, ...	496,045	9,213,556	295,666	9,440,943
1883, ...	433,602	7,944,982	118,062	3,834,740
1884, ...	283,172	4,932,598	7,971	252,446
1885, ...	151,959	2,689,263	4,203	104,494

The above table exhibits the magnitude of our imports of iron and steel in a light that may well startle the reader. And yet it embraces only three products, pig-iron and iron and steel rails. Full statistics of all our imports of iron and steel for the whole period covered by the table are not available. In the following table we give our imports of old iron rails, old iron, and scrap-iron for the fifteen calendar years from 1871 to 1885. Iron in these forms takes the place of pig-iron:

Years.	Gross tons.	Values.	Years.	Gross tons.	Values.
1871, ...	196,732	$4,845,092	1879, ...	221,812	$3,700,200
1872, . . .	248,444	7,617,463	1880, ...	619,887	14,704,879
1873, ...	97,177	3,061,759	1881, ...	134,917	2,705,072
1874, ...	36,279	949,752	1882, ...	146,956	2,736,483
1875, ...	25,846	498,682	1883, ...	64,286	1,014,863
1876, ...	12,633	236,596	1884, ...	26,957	340,420
1877, ...	9,735	140,593	1885, ...	13,821	151,714
1878, ...	5,558	65,619			

Our imports of tinplates have in recent years assumed extraordinary proportions. The following table shows their growth in the calendar years from 1871 to 1885. All our imports of tinplates come from Great Britain. We do not ourselves make one pound of tinplates:

Years.	Gross tons.	Values.	Years.	Gross tons.	Values.
1871, ...	82,969	$9,946,373	1879, ...	154,250	$13,227,659
1872, ...	85,629	13,893,450	1880, ...	158,049	16,478,110
1873, ...	97,177	14,240,868	1881, ...	183,005	14,886,907
1874, ...	79,778	13,057,658	1882, ...	213,987	17,975,161
1875, ...	91,054	12,098,885	1883, ...	221,233	18,156,773
1876, ...	89,946	9,416,816	1884, ...	216,181	16,858,650
1877, ...	112,479	10,679,028	1885, ...	228,596	15,991,152
1878, ...	107,864	9,009,967			

In the following table we give the values of all our imports of iron and steel, including pig-iron, iron and steel rails, bar iron, plate and sheet iron, old rails, scrap iron and scrap steel, cotton ties, steel in miscellaneous forms, tinplates, wire rods and wire, fire-arms, hardware, cutlery, machinery, etc., in the fifteen calendar years from 1871 to 1885.

Years.	Values.	Years.	Values.	Years.	Values.
1871, ...	$57,806,299	1876, ...	$20,016,603	1881, ...	$61,555,077
1872, ...	75,617,677	1877, ...	19,874,399	1882, ...	67,075,125
1873, ...	60,005,538	1878, ...	18,013,010	1883, ...	47,506,306
1874, ...	37,652,192	1879, ...	33,331,569	1884, ...	37,078,122
1875, ...	27,363,101	1880, ...	80,443,362	1885, ...	31,144,530

The above values aggregate $674,542,910, a sum so large that, in the absence of the accompanying statistics of production which we have presented it, would seem to the uninformed reader that our iron and steel industries had not been fully developed during the last fifteen years.

The comparative table which is here given is in gross tons of 2,240 pounds for the United States and Great Britain, and in metric tons of 2,204 pounds for all other countries. Miscellaneous castings from the blast furnace in some of the Continental countries of Europe we have counted as pig-iron.

PRODUCTION *of Pig-Iron in the Last Twenty-one Years in the Principal Iron-Producing Countries.*

YEARS.	GROSS TONS OF 2,240 POUNDS.		METRIC TONS OF 2,204 POUNDS.					
	Great Britain.	United States.	Germany.	France.	Belgium.	Austro-Hungary.	Sweden.	Russia.
1865, . .	4,819,254	831,770	. . . . .	. . . . .	470,767	. . . . .	. . . . .	. . . . .
1866, . .	4,523,897	1,205,663	. . . . .	1,260,348	. .	319,709	. . . . .	. . . . .
1867, . .	4,761,023	1,305,023	1,113,606	1,229,044	423,069	361,038	. . . . .	. . . . .
1868, . .	4,970,206	1,431,250	1,264,347	1,235,308	435,754	425,071	. . . . .	. . . . .
1869, . .	5,445,757	1,711,287	1,413,029	1,380,965	534,319	450,567	285,065	. . . . .
1870, . .	5,963,515	1,665,179	1,391,124	1,178,114	565,234	452,244	293,438	354,032
1871, . .	6,627,179	1,706,793	1,563,682	859,641	609,230	476,627	293,277	353,710
1872, . .	6,741,929	2,548,713	1,988,394	1,217,838	655,565	531,850	334,788	393,065
1873, . .	6,566,451	2,560,963	2,240,574	1,366,971	607,373	594,980	339,685	378,387
1874, . .	5,991,408	2,401,262	1,906,262	1,423,308	532,790	545,742	332,154	374,355
1875, . .	6,365,462	2,023,733	2,029,389	1,416,228	540,473	504,347	343,551	420,484
1876, . .	6,555,997	1,868,961	1,846,345	1,453,112	490,508	450,933	344,834	. . . .
1877, . .	6,608,664	2,066,594	1,932,725	1,400,000	470,488	409,000	336,370	. . . .
1878, . .	6,381,051	2,301,215	2,147,641	1,417,072	493,544	424,249	333,496	409,693
1879, . .	5,995,337	2,741,853	2,226,587	1,344,759	448,371	404,160	342,547	429,865
1880, . .	7,749,233	3,835,191	2,729,037	1,725,293	595,704	465,518	405,765	441,285
1881, . .	8,377,364	4,144,254	2,914,009	1,899,861	624,736	543,000	435,428	462,027
1882, . .	8,493,287	4,623,323	3,380,806	2,039,067	727,000	611,681	398,945	498,400
1883, . .	8,490,224	4,595,510	3,469,719	2,067,387	770,659	710,037	422,027	. . . .
1884, . .	7,528,966	4,097,868	3,572,155	1,855,247	750,812	771,502	430,534	. . . .
1885, . .	7,250,657	4,044,526	3,751,775	1,629,051	714,677	805,631	425,000	. . . .

This table shows that during the last twenty-one years Great

Britain increased its production of pig-iron from the first year named in the table to the highest annual product 76 per cent.: the United States, 456 per cent.; Germany, 237 per cent.; France, 64 per cent.; Belgium, 64 per cent.; Austro-Hungary, 152 per cent.; and Sweden, 53 per cent. Next to the United States, Germany has made the greatest relative progress in this period in the production of pig-iron. The country which has experienced during the past few years of general depression the most serious check in the growth of its pig-iron industry is Great Britain. years gone by, the large importations of pig-iron and of finished iron and steel from Great Britain into this country have been a very important factor in building up the British iron and steel industries, but these importations have now very greatly diminished. It is exceedingly probable that the gap which now separates our production of pig-iron from that of Great Britain will be entirely closed within the next five years, if the rates of duties now imposed by the United States on foreign iron and steel are maintained for that length of time.

As late as 1871, Great Britain made one half of all the pig-iron made in the world; since that year, her proportion of the world's production has steadily declined.

The World's Production of Pig-Iron.—From the most reliable information that is obtainable, in addition to the statistics which are embodied in the preceding table, giving the production of pig-iron by eight leading countries, we submit the following table of the world's production of pig-iron at various periods since the close of the last century:

Years.	Gross tons.	Years.	Gross tons.	Years.	Gross tons.
1800, ...	825,000	1870, ...	11,900,000	1879, . . .	13,950,000
1830, ...	1,825,000	1871, ...	12,500,000	1880, . . .	17,950,000
1850, ...	4,750,000	1872, ...	13,925,000	1881, . . .	19,400,000
1856, ...	7,000,000	1873, ...	14,675,000	1882, . . .	20,750,000
1865, ...	9,250,000	1874, ...	13,500,000	1883, . . .	21,000,000
1866, ...	9,800,000	1875, ...	13,675,000	1884, . . .	19,475,000
1867, ...	9,850,000	1876, ...	13,475,000	1885, . . .	19,100,000
1868, ...	10,400,000	1877, ...	13,675,000		
1869, ...	11,575,000	1878, ...	13,925,000		

After our civil war there was a great industrial awakening in this country, beginning in 1865, and after the Franco-German war of 1870 there was a similar awakening in France and Germany, but especially in the latter country. This industrial activity, which largely increased the demand for iron and steel, affected the world's iron and steel industries in a marked degree. The increasing use of iron and steel in ship-building, in bridge-building, and for general constructive purposes, has also largely increased the demand for both these products. Finally, the American "boom" of 1879 and 1880, following after years of enforced economy in the use of all manufactured articles, gave a fresh and remarkable stimulus to the demand for iron and steel in this country, which the whole world's resources were taxed to supply.

Conclusion.—It has been the object of this paper to exhibit the astonishing progress of the United States in the manufacture of iron and steel in the last twenty-one years, and to show the prominence of our country as a producer of these essential aids to modern civilization. This has been done. It is not necessary to look closely into the future of our iron and steel industries. That they will continue to grow and prosper as the country grows and prospers, may be taken for granted. With an abundance of good ores and good fuel, including under the latter head our large stores of natural gas, we must soon become the first iron and steel producing country in the world, as we have long been the largest consumer of these products. Only Great Britain excels us in the production of pig-iron and steel, but we annually consume more of each product than our great rival. We consume to-day one fourth of all the pig-iron and one third of all the steel that the world produces.

WOOD PULP.—Mr. Mark L. Deering, in a paper entitled "Wood Pulp, and Some of its Peculiarities," says: Pulp originally meant the soft parts of bone and animal structure, especially the marrow. Then the softer portions of certain fruits, until the digested straw and rags used in making paper was called pulp. As the wood was used first as an adulterant in paper-making, it naturally took the name of pulp, not an inappropriate one.

The woods used are poplar, white and yellow pine, spruce, and cottonwood, the pulp made from the last-named being by far the best, and also much the highest in price.

The general mode of manufacture is to saw the logs up into billets of about one foot long, the bark being then carefully peeled off. After this the billets are boiled, in order to extract the sap, and ground by means of special machinery. After being ground, it is digested in a vat with linen stock, jute, or other material, in order that it may possess the necessary tenacity of fiber. To give consistency and weight, clay is added, which also fills up the interstices and makes the mass present a better appearance. Sizing is necessary; rosin, glue, starch, and sometimes Irish moss are mixed carefully throughout until the requisite adhesiveness is obtained.

The principal uses to which it is put are in newspaper stock, all fine printing papers, wall paper, (almost exclusively,) water pails, tubs, wash basins, ink bottles, boats, observatory domes, and gunpowder. The gunpowder is claimed to ignite freely and be of great strength, but is very expensive.

* * *

IN THE interpretation of our tariff provisions, the Treasury Department seem determined to maintain its reputation for discrimination against American interests. The decision that a ton of commercial iron ore was that weight of ore after it had been dried at 212° Fahrenheit, and all moisture other than combined water driven off, is, to say the least, farcical. Probably, the next decision will be, that as a tariff is placed on "iron in bars, blooms, etc.," a ton of blooms will be rated according to the *iron* it contains after deducting all phosphorus, manganese, silicon, carbon, sulphur cinder, etc., contained therein. Foreign ores are sold according to the iron they contain and the absence of deleterious substances, and pig-iron, bar-iron, blooms, etc., are valued upon similar bases. If the late decision of the ore question is based on equity, its rulings will cover iron in pigs, blooms, billets, etc.

* * *

A FOREST tree plantation, begun 25 years ago by an Illinois farmer, has for some years past yielded fuel for three families, poles, stakes, and posts for fences, an abundant supply of maple syrup, nuts of various kinds, a valuable shelter for the homestead and the live stock, protection for the orchard and garden, and verdant groves for the recreation and delight of his family.—*Western World.*

SOME elaborate experiments with various woods, brought from the British colonies, were lately made in England, there being some forty samples under examination, obtained from New South Wales, Victoria, South Australia, Western Australia, New Zealand, Canada, Cape of Good Hope, British North Borneo, and India. The woods were of every description, from the hardest iron bark to the soft mild-working Douglas fir of Canada; in all cases the samples left the machine with the same smooth finish, the only difference being that the harder qualities of wood were passed through the machines at a somewhat slower rate. A number of different operations were successfully carried out on them, such as tree-felling, cross-cutting, sawing, planing, molding, mortising, and tenoning, besides which several articles were made completely, such as casks and barrels, doors, hammer and pick handles, carriage spokes, railway sleepers, &c. The iron bark and mountain ash from New South Wales was well suited for wheelwright work, piles, and railway sleepers. The black wood from Victoria was found well suited for cabinet work; karri wood and jarrah from Western Australia were both useful for joiner's work, furniture, sleepers, and piles. The New Zealand woods were well adapted for furniture, house-building, and general purposes, kauri being especially useful. The Canadian woods, such as the Douglas fir and swamp ash, were suitable for building purposes. The sneeze wood from the Cape, owing to its unusual durability, was well adapted for piles, posts, telegraph poles, &c., and the tellon wood was like lance-wood and made excellent doors. The billian and sarayah woods from North Borneo were very useful woods. The padouk wood from India was well suited for carriage building, furniture, &c.

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DURING the year 1886, to November 1, about 4,000 miles of railway have been laid. The *Railway Age* says every new mile of railway calls for the employment of five more men, and hence permanent employment has been furnished this year to something like 20,000 additional men. It estimates that the employés of the railways in the United States already number not less than 650,000 men.

NOVEL TEST FOR SHRINKAGE AND CHILLS.—The manager of a large stove foundry suggests a method which he pursues, which presents sufficient novelty to be chronicled, and which may lead others to investigate the merits of the plan. We quote from a letter received from him, in which he makes inquiry as to a source from which he can obtain reliable high silicon pig-iron:

"We use silicon pig, but of very variable quality, and have no way of finding out except by special analysis; besides, difficulties present themselves, viz: The silicon is not high enough, as I want from 10 per cent. up, the higher the better. Also, iron that we purchase as silicon pig receives its appearance from other causes than silicon, or else some other admixture with silicon. My plan is, and has been, to eventually obtain shrinkage and chill tests of known combinations to use as standards of comparison, and by which the chemical constitution of one pig can be easily and rapidly estimated. I have peculiar test-bars which give me the shrinkage to $\frac{1}{2000}$ of an inch of the edge away from, and on side of, the gate of a $\frac{1}{2}$-inch square bar, and of a companion bar run with it 1 inch × $\frac{1}{8}$ inch, and both 1 foot long. The ends run against a chill $12\frac{1}{8}$ inches opening, and the bars are measured in the chill in which they were cast to obtain shrink. I also get depth of chill and observe structure and much else. I have very accurate apparatus, and have recorded results on all shipments of iron that we have received for two years, and have tested samples from a large number of furnaces that we do not deal with. It is evident, from results obtained, that the peculiarities of shrinkage will tell of what the iron contains, but to do so I must get a series of comparative records.

"I hope I have succeeded in ordering a Swedish pig free from combined carbon, and comparatively free from silicon, phosphorus, and sulphur, and manganese, to use as a base. You may wonder why I do not resort to analysis, but I think the results will not be as satisfactory, and I do not wish to go to the expense if I can get the silicon pig necessary. Phosphorus, and sulphur, and manganese are easily added in known quantities. For two years, I have made my mixture according to test results with the greatest success, and have found the same results that are mentioned by late experimenters, and hope before long to have found out the exact meaning of the records I have obtained."

Minutes of the Seventh Annual Meeting of the United States Association of Charcoal Iron Workers.

FIRST SESSION.

PARLOR C, CONTINENTAL HOTEL, *October* 9, 1886.

The members of the Association in attendance at the annual meeting were called together at 8.30, P. M., with President J. C. Fuller in the chair. After words of welcome from the President, letters of regret were presented, upon which some discussion was had (as appears in the "Narrative of the annual meeting.") The Secretary then presented his report, together with the financial statement, which were as follows:—

PHILADELPHIA, *November* 1, 1886.

To the Board of Managers of the United States Association of Charcoal Iron-Workers:

GENTLEMEN:—The year which has just closed has been one of severe trial for the organization; the business depression which was referred to in the report of last year having continued, and the revenue available having decreased. It is hoped that the apparent revival of business will bring with it encouragement for our Association, and secure for it a continuance on a broader scale than heretofore attempted. That an organization composed chiefly of manufacturers of specialties should suffer from a general business depression was to be expected, but the effect has been more marked than was anticipated, and would have been discouraging were it not for the generous support tendered from many of our members, and the strong protests coming from all sections against any contemplated curtailment of the efforts of the organization. Had the Association confined its work merely to meetings, conferences, and correspondence, the revenue collected would have been sufficient to cover the necessary outlay; but the publication of a journal devoted to the interests of the charcoal iron trade, has required expenditures greater than the income; and, as a precautionary measure, the interval between the issues was extended, until such time as the Association could take action in the premises.

That our JOURNAL is appreciated is evidenced by the inquiries which this restricted publication encouraged, and by the prompt requests which follow the miscarriage of any issue for duplicate copies. In addition to this, the number of complete sets of JOURNALS purchased is encouraging proof of the esteem in which it is held.

The financial statement will show that the deficit given in the last report has been reduced, but that the Association is still in debt. Had all the dues assessed been paid, this would not have been the case, for our books show that the arrearage amounts to $460. Some of this is owing to oversight, but fully one third of the amount is due from companies which have gone into liquidation. In an organization of this character, with a small annual assessment, members are liable to procrastinate in settlements, and the courtesies so generously extended by those who entertain the Association naturally encourage a proportion of transient members.

At the date of the last report, the roll of the Association included		317 members.
During the year the deaths, resignations, and those dropped on account of default of dues numbered	40	
The new members added were	9	
Showing a loss of ten per cent.		31
And making our present membership		286 members.

Of these, 269 are located in twenty-five States and one Territory, the remaining 17 being resident in nine foreign countries.

The geographical distribution of the members and associates, as given by States and countries, is exhibited in the following statement, which shows that the support of the organization comes from all of the charcoal iron producing centers in nearly the proportions of their relative importance.

Pennsylvania,	62	Georgia,	4
Michigan,	29	Massachusetts,	3
Missouri,	29	Minnesota,	3
New York,	26	Texas,	3
Ohio,	24	Virginia,	3
Connecticut,	14	Washington Territory,	2
Alabama,	12	West Virginia,	2
Tennessee,	12	Colorado,	1
New Jersey,	9	Iowa,	1
Wisconsin,	7	Kentucky,	1
Illinois,	6	Maine,	1
Maryland,	6	Oregon,	1
Indiana,	4		
Delaware,	4	Total,	269

FOREIGN MEMBERS.

Canada,	4	Hungary,	1
Sweden,	4	Prussia,	1
Austria,	2	Servia,	1
Mexico,	2		
England.	1	Total,	17
France,	1		

To illustrate the present status of the Association in comparison with the record of previous years, the annexed statement is submitted:

	YEAR ENDING					
	Oct., 1881.	Oct., 1882.	Oct., 1883.	Oct., 1884.	Oct., 1885.	Oct., 1886.
Honorary members,	8	8	10	11	9	9
Foreign members,	6	10	12	8	10	11
Members	186	239	267	277	243	209
Associates,		16	51	68	55	57
Total,	200	273	340	364	317	286

With a continuous existence of seven years, the organization should make a better showing than the above, and it would do so if the membership generally would feel the necessity of presenting its claims personally to those who would probably connect themselves with it. Its roll is far from containing all who should find it advantageous to be connected with the Association, but these cannot be reached by the officers of the organization, and a little personal effort from each member would be most welcome to the management.

Financial Statement.

Receipts and Expenditures from October 14, 1885, to November 1, 1886.

	DR.	CR.
To cash balance on hand, October 14, 1885,	$82 53	
RECEIPTS.		
To amount received for dues,	1,279 92	
To amount received for advertisements,	59 62	
To amount received for JOURNALS and contributions,	368 05	
	$1,790 12	

Of this amount $40 have been paid for dues of 1887.

DISBURSEMENTS.

By office expenses, clerical labor, postage, telegraphing, expressage, and incidentals, ...	$ 374 96
Printing JOURNALS, ...	560 83
Stationery and printing, ...	36 25
Expenses of meetings and stenographers, ...	70 63
Engraving for JOURNALS,.	19 50
Salary of Secretary for 1885, ...	575 30
	$1,637 47
Cash balance, November 1, 1886, ...	152 65
	$1,790 12
Bills of Lane S. Hart and E. K. Meyers, outstanding	$478 75

JOHN BIRKINBINE,
Treasurer and Secretary.

This report and statement being before the meeting, a general discussion was held; and, on motion of Col. Geo. B. Wiestling, of Pennsylvania, a Committee on Finance was appointed, as follows:

Geo. B. Wiestling, Esq., W. N. McGugin, Esq., and W. R. Davenport, Esq.

On motion of Mr. M. Lyman, of New York, the Committee on Nominations were appointed to consider and suggest appropriate names for the officers to serve during the ensuing year.

This committee were M. Lyman, R. H. Lee, and C. E. Coffin.

By the request of the President, the Secretary gave a brief sketch of the new Gogebic Iron Range in Northern Michigan and Wisconsin (which appears in this issue of the JOURNAL).

On motion, adjourned.

SECOND SESSION.

PARLOR C, CONTINENTAL HOTEL, *October* 10, 1886.

Meeting called to order at 8.30, P. M., with President Fuller in the chair. The Secretary read a paper by Dr. Herman Wedding of Berlin, Prussia, upon the "Difference in the Microscopical Structure of Coke and Charcoal Pig-Irons," together with some extracts from a paper published by Dr. Wedding in the British Iron and Steel Institute Transactions. After a general discussion and exhibition of specimens of iron under the microscope by Mr. F. L. Garrison, of Philadelphia; Col. Wiestling offered the following, which was adopted:

Resolved, That the thanks of the United States Association of

Charcoal Iron Workers are hereby tendered to Dr. Herman Wedding, of Berlin, Prussia, and Mr. F. L. Garrison, of Philadelphia, for their able and interesting contributions upon the subject of the microscopic structure of pig-irons.

On motion, Mr. O. W. Davis, Jr., of Maine, moved that a committee on courtesy be appointed, and the President named Messrs. O. W. Davis, Jr., and Geo. H Russel.

On motion adjourned.

THIRD SESSION.

PARLOR C, CONTINENTAL HOTEL, *October* 11, 1886.

The meeting was called to order at 11, A. M. President Fuller in the chair. The first business in order was the report of the Finance Committee, which was as follows:

"The committee to whom was referred the consideration of the financial condition of the Association, respectfully report its conclusion, and opinions to be:

The fact is presented that the liabilities of the Association, are:

Unpaid bills (matured) for printing and binding JOURNAL, . . .	**$478 75**
Unpaid salary of Secretary and Treasurer (past mature), ...	**467 78**
Total indebtedness past due, ...	**$946 53**
To meet this indebtedness, we had on hand at the opening of this meeting, cash balance of	**$152 65**
Association *vs.* members for arrears of dues, $460—of which 50 per cent. only are considered as available, ...	**230 00**
Total, ...	**$382 65**
Leaving a balance due by us for which provision must be made, .	**563 88**
	$946 53

There are over two hundred active members upon the roll, who can, we believe, be relied upon to lend their full proportion of assistance to cancel this obligation, for it is assumed that there are none among our number who would seek in any way to escape from any obligation affecting the reputation and integrity of our Association.

An increase of five dollars per active member is recommended to be made at once in addition to the regular dues.

It is believed that this will be promptly paid, and thus one thousand dollars will be provided to meet the liabilities of the past. We even dare to express the hope that a knowledge of the true condition of affairs as herein set forth, will prompt the generous hearts of those among our members who feel warranted in so doing, to contribute a larger sum than the increase named.

While the adoption of this course will relieve the pressing immediate wants of the treasury, your committee desire to emphasize their conviction that further decided and radical action is necessary to place the Association on a substantial basis, and thus prevent a probable recurrence of the same deplorable condition.

The time given to consider this feature of the subject is entirely too brief to enable us to do justice to our own convictions. We believe this limited time afforded us, as well as the necessities which called us into existence, are both attributable to one cause, and that is a radical defect in the character, scope, and customs of our Association.

The remedies for these conditions, we believe, should be fully digested by a committee who can give more time and thought to the question than is possible for us, and it occurs to us that the Executive Committee is the proper body to whom the subject should be referred.

We briefly suggest, however, that the custom of changing the President and Executive Committee each year is prejudicial to the best interests of the Association, and recommend that the custom be abolished. Questions such as those now pressing upon us would be less likely to arise under the changed condition proposed, and suggestions looking to the perpetuity—the increased usefulness—the permanent efficiency of our organization would receive such careful thought and such wise solution as is impossible under existing circumstances. Under a modification something like this proposed, we believe that only the provisions of Article IV of the constitution can be carried out."

GEORGE B. WIESTLING,
W. N. MCGUGIN,
W. R. DAVENPORT,
Committee.

After a general discussion of the report, Mr. Joseph D. Potts offered the following resolution, which was adopted without dissent:

Resolved, "That the annual dues for the year 1887 be increased

$5.00 per active member, for the purpose of extinguishing the debt of the Association and to permit of extending its usefulness."

The Committee on Nominations, through Mr. Lyman, chairman, then reported the following nominations, which, on motion, were unanimously approved, and the gentlemen named were designated as the officers of the Association for the ensuing year:

President.– J. C. Fuller, Pine Grove Furnace, Pa.

Vice Presidents.—W. R. Davenport, Erie, Pa.; O. W. Davis, Jr., Bangor, Me.; W. H. Lee, St. Louis, Mo.

Board of Managers.—Willard Warner, Tecumseh, Ala.; H. R. Stoughton, Shelby Iron Works, Ala.; W. H Barnum, Lime Rock, Conn.; M. H. Robbins, Lakeville, Conn.; E. Sjosdedt, Bangor, Maine; Geo. G. Lobdell, Wilmington, Del.; A. G. West, Cedartown, Ga.; H. S. Pickands, Chicago, Ill.; J. H. Bass, Fort Wayne, Indiana; John Gibson, Creston, Iowa; R. A. Burgett, Richmond, Mass.; C. E. Coffin, Muirkirk, Md.; Lee Burt, Detroit, Michigan; W. H. Rood, Ishpeming, Mich.; Geo. H. Russel, Detroit, Mich.; Geo. F. Baker, St. Louis, Mo.; H. A. Crawford, St. Louis, Mo.; F. G. Neideringhaus, St. Louis, Mo.; M. Hoagland, Rockaway, N. J.; W. A. Miles, Copake Iron Works, N. Y.; Moses Lyman, Waverly, N. Y.: Geo. S. Frink, Irondale, N. Y.: S. Frank Eagle, Cecil, Ohio: W. N. McGugin, Olive Furnace, Ohio; J. F. Holloway, Cleveland, Ohio; E. W. Crichton, Oswego, Oregon; Jos. D. Potts, Philadelphia, Pa.; Henry Whiteley, Philadelphia, Pa.; L. Heber Smith, Joanna, Pa.; H. T. Townsend, Philadelphia, Pa.; Frank McCoy, Milesburg, Pa.; E. C. Converse, McKeesport, Pa.; Geo. B. Wiestling, Mont Alto, Pa.; A. F. Huston, Coatesville, Pa.; Charles Cobb, Marshall, Texas; Frank King, Van Buren Furnace, Va.; Irving M. Bean, Milwaukee, Wis.; Chas. H. Brown, Knoxville, Tenn.; Jas. C. Warner, Nashville, Tenn.; J. L. Smith, Irondale, Washington Territory; S. M. Buck, Coalburg, W. Va.

The Committee on Courtesies submitted, through Mr. Davis, the following report:

The United States Association of Charcoal Iron Workers in Convention at Philadelphia:

Resolve, That the hearty thanks of the organization are due, and are hereby tendered, to the Iron Trade, and to the citizens of Philadelphia who so warmly welcomed and entertained us; to the

Pennsylvania Railroad for their generous courtesy in placing a special train at our disposal; to the Wilmington and Northern Railroad for courtesies extended; to our hosts, the Lobdell Car Wheel Company, the McCullough Iron Company, and Mr. J. A. Mathieu, for the bountiful luncheon spread upon the train; to the Harlan and Hollingsworth Company; the Pusey and Jones Company; the McCullough Iron Company; Messrs. Seidel, Hastings & Company; the Wood Extract Company; the Chester Oil Works; the Chester Rolling Mills; the Chester Tube Works; the Baldwin Locomotive Works, and Messrs. A. Whitney & Sons, for the gratification and instruction given, by the opportunity of visiting their industrial establishments. The Association would also record its thanks to the proprietors of the Continental Hotel, who have furnished so convenient and comfortable a headquarters for the meeting.

On motion, adjourned subject to the call of the Executive Committee. JOHN BIRKINBINE, *Secretary.*

The newly elected Board of Managers met and elected as the Executive Committee, Messrs. Joseph D. Potts, George G. Lobdell, and Charles E. Coffin.

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THE *North-Western Lumberman* remarks that the extent to which tapping a yellow pine tree injures the timber is a question that has not been decided. There are men who assert that lumber produced from the timber cut in a turpentine district is not so good as that from trees which were never boxed, yet if the two kinds of lumber be laid side by side, they are unable, oftener than otherwise, to tell which is which. Government contracts for yellow pine specify that it must be unboxed, but it is an open secret that Government timber inspectors cannot detect the difference, and as a result the contractor is not particular to follow the instructions of the document by which he is supposed to be guided. The absence of pitch in the wood is generally supposed to be evidence that the tree was tapped. The evidence is misleading, however, for tapped timber is sometimes full of pitch. The subject is one which, theoretically, has caused some commotion, but which, practically, so far as we have observed, is of less importance than has been ascribed to it by many.

The Gogebic Iron Range.*

By JOHN BIRKINBINE, *Philadelphia.*

[Presented at the Seventh Annual meeting of the United States Association of Charcoal Iron Workers.]

For a number of years, prospectors for iron-ore properties have been interested in the development of a district (of which test-pits had given favorable indications) lying close to the western boundary of the upper peninsula of Michigan, and at one time the exploitations of some large iron corporations led to the expectation of speedy development: but the absence of transportation facilities, and the abandonment of the work by these iron companies, caused a decided set-back to the region, and it was not until 1885 that railroad connection to Ashland, on Lake Superior, was assured, and the development of what is now known as the Gogebic Iron Range became an assured fact.

LOCATION.

Geographically, the Gogebic Iron Range may be described as running nearly parallel with the southern shore of Lake Superior, and about fifteen miles distant from it. The Montreal river, (which is the boundary between the State of Wisconsin and the upper peninsula of Michigan,) flowing northward into the lake, cuts through the range nearly midway between the extremes of present exploitations. About one half of the ore deposit, as now believed to be determined, lies in Ontonagon county, Michigan, and the other half in Ashland county, Wisconsin. The natural center of business is, therefore, at this passage of the Montreal river, the town of Hurley, Wisconsin, being the objective point of travelers to this region. A growing settlement, called Ironwood, across the river and the town of Bessemer in Michigan, are rivals to Hurley.

The remarkable extent of rich magnetites and specular ores in the Marquette region, followed, a few years ago, by the phenomenal development of the Menominee district, has already made this "New North" famous, and the Gogebic Range is at present adding to this reputation. These, together with the valuable copper

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***Much of this paper has since been published in a series of articles in the *Iron Age.* We expect in a future issue to give data as to analyses of ores, cost of mining, etc.—[ED.]**

ores of the Keweenaw Peninsula, with Silver Islet as their *vis à vis*, the Sault Ste. Marie at the eastern end, the lately-developed Vermillion ore district of Minnesota, and the magnificent water-power of the St. Louis river, at the western end of Lake Superior, seem to indicate that this great inland sea, 600 feet above ocean-level, is surrounded by a cordon of nature's richest gifts to man, and, although one may be skeptical, he must naturally look for something beyond the ordinary in any new development of this favored section.

The Milwaukee, Lake Shore and Western railroad bears nearly west through the upper Michigan peninsula, passing to the south of the Gogebic Range, and then crossing to the north of it, where the Black river cuts through the hills. For about 15 miles, the railroad is nearly parallel with the Gogebic Range, but shortly after entering Wisconsin, and passing Hurley, it bears away from it toward Ashland, its present terminus, and the shipping port for Gogebic ore.

The Wisconsin Central railroad is now constructing a line along the Penokee and Gogebic ranges, thus giving competitive freight rates to the lake. A connection eastward to Escanaba, through the Menominee ranges, is also reported as under contract, and other railroad projects are ventilated.

GEOLOGY.

Mr. T. B. Brooks, in "Iron-Bearing Rocks," (a part of Geological Report of Michigan, Vol. I, 1873, page 183–186,) says of what is now the Gogebic Iron Range: "The iron range may be regarded as the eastern prolongation of the Penokee range in Wisconsin, as well as the western extension of the Marquette series, the whole being Huronian. * * * Here will be found banded ferruginous jaspery schists, chloritic green stone, brown ferruginous slates, black and gray banded silicious slates, silicious flag-ores, several varieties of quartzites, and clay slate. The whole series strike east and west, and dip north away from the granites and gneisses, and under the copper rocks, at an angle of from 40° to 90.° * * * The rocks, although somewhat different from the Huronian series of the Marquette region, are still essentially the same, and I know of no good reason why merchantable ores may not be found among them. * * * The best 'show' is on the northeasterly side of the east and west ridge, where there is a large exposure of ferruginous quartzite in places holding hand-specimens of hematite ore of fair quality. As this kind of ore never outcrops, on account of its soft, earthy character, and as we had no facilities for digging, nothing more definite was determined."

The existence of ore has been recognized for fully 20 years, and its distance from transportation facilities has been one prevailing cause for a failure to develop it. The amount of work done within the last two years has been so great as to dwarf former efforts, but the faith of the early explorers has been firm during years of discouragement, and it is gratifying that some of those who pioneered in the wilderness live to-day reaping the benefits of their efforts.

The mooted question in the Gogebic Iron Range is as to whether or not there are two well-defined ore veins, and champions of one vein, of two veins, or of even three veins are plenty. The ideal cross section of the measure, as published for the information of prospective investors, is as follows: A hill is shown with its north and south flanks, and its summit covered with drift of varying widths, but heaviest at the base. This is supposed to be a transverse section through the ridge forming the Gogebic Iron Range. Under the drift the southern flank of the ridge is shown as granite, then quartzite 60 to 80 feet in width, dipping north about 70°; the south ore vein 40 to 140 feet in width on the same dip; then a cap of quartzite and mixed ore; then slates and quartzites, with occasional ore 330 to 360 feet thick; then a foot-wall of red slate, against which the north vein rests 25 to 90 feet, and which lies on the 70° dip, being capped with quartzite and mixed ore 10 to 12 feet in thickness, overlaid by soap rock 30 to 40 feet; then banded slate quartzite and ore 150 feet in width, the talus of the north flank of the ridge being of black slate covered by drift. While the maximum widths of the north and south veins—if they really exist as veins—have been reached in certain mines, the minima are less than given in the ideal section above described.

The occurrences of ores similar in character to those of the Gogebic iron range in lenses or pockets in the Marquette and Menominee ranges naturally point to like deposits in this newer district, and there seems good reason to believe that the ores lie in lenses of greater or less width and depth throughout an ore-bearing strata confined by the quartzite hanging wall of what is believed to be the north vein, and the foot wall of what is usually known as the south vein, with a greater probability of finding the ore in this newer region, owing to the apparent persistence of the foot wall. Local opinions, however, favor, and not without reason, the existence of two veins, although the presence of two apparently distinct ore bodies is shown so far in but few instances. The belief in the existence of two veins is based upon their relative positions to the foot wall, and also to a greater percentage of manganese in the south vein. The strongest argument in favor of two veins seems to be the exhibit at the Colby open quarry, but the late developments where the "horse" in the north vein hereinafter referred to seems to have crowded the ore and foot wall from a north to a south dip, and the cross-cutting from the south vein, which is approaching the development of the north vein, are by many believed to indicate a union of the two apparent veins under an immense horse of rock.

THE OUTLOOK.

Whether the ore exists in one vein, branching at times into two or more, or whether, as in the Marquette and Menominee districts, there are lenses of greater or less magnitude scattered through a well-defined strike of ore-bearing rocks, affects the future of the Gogebic Iron Range and the interests of individual properties rather than the iron trade at large, for the following facts are beyond question:

1. The mines already opened and worked show a high grade of red hematite ores, most of which are strictly of the Bessemer class, the balance of the ore prepared for shipment being rich in iron and close to the Bessemer limit in phosphorus. While some ores high in manganese are mined, none can be said to be high in phosphorus, and it is doubtful if the run of any of the developed properties would show 2 parts of phosphorus to 1,000 of iron.

2. The Gogebic Iron Range shipped in 1885, the first year of its development, 111,661 tons. In 1886, 724,617 tons were mined and shipped up to November 24, and the dead work and development which will be carried on during the winter months (when,

because of lake transportation being closed, the shipping must be suspended, except of the ore sent by rail to Wisconsin furnaces and the possible shipments by the same means to Chicago,) will place the region in condition to largely augment its output in 1887; for the mines which have been shipping ore in 1886 will endeavor to augment their product in 1887, and in the coming season a number of mines which have only been developed, waiting for the railway sidings, or which were in 1886 but test pits, will enter the list as shippers of ore. It is within a safe estimate to place the output of this the Gogebic Iron Range in 1887 at 1,000,000 tons, and if the stiffening in prices continues, it is not improbable that it may exceed this quantity.

3. Although wages are high in the new district, $1 75 being paid for surface labor, $1 85 for pit labor, and $2 per day for miners, ore can be mined cheaply at several of the large mines, and there need not be any scarcity of good Bessemer ores at the prices now ruling.

4. The demand for shipping facilities on the lakes which the Vermillion and Gogebic Iron Districts produced, and which caused a rise in lake freights this year, will to a certain extent be remedied by the large additions to lake craft in course of construction at the various shipyards, all of which are busy, and notwithstanding the heavy losses caused by storms, the transportation facilities on the Great Lakes will in 1887 be much in excess of what they were in 1886.

MINING METHODS.

In a region developed so recently as the Gogebic Iron Range, we naturally look for crude mining appliances, inferior machinery and equipment, inefficient management, or injudicious methods. To assert that these do not exist would be untruthful, but to do justice to the region at large, it is but fair to say that such imperfections are less numerous and prominent than would be expected in a section whose development has been so rapid. As a rule, the machinery plant is good, but in many cases it is too small for working the mines advantageously in the future. A number of the mines are in the charge of experienced captains who have won a reputation for themselves in other iron districts. The methods of mining have been influenced to a considerable extent by the desire to get the ore out promptly and place the mine in the list of producers, with the object of appreciating the market value of the stocks, for, with but few exceptions, all of the territory believed to be within the strike of the ore-bearing rocks is placed in mining companies, and generally each 80 acres is capitalized at $1,000,000. Some of the development work is a continuation of the prospecting shafts to which hoisting appliances have been added, and is not such as more thorough study would have dictated. But two of the mines have been equipped with air compressors, and the use of the rock drill is in its infancy in the Gogebic Iron Range. In most cases, the ore is comparatively soft, and black powder is even more efficacious than the higher explosives. As the dip of the ore-bearing rocks is 65° to 70°, the usual method has been to open a slope on the foot wall, carrying it down on this wall of quartzite and drifting in levels from it. Some of the mines where the drift resting upon the ore deposit was light show open cuts, and in these the skip roads are laid on the foot wall.

Two methods of raising the ore are prominent, viz: Skip cars running upon rails in vertical shafts or incline slopes which are continued into a tower, where the contents of the cars are dumped automatically into shutes or into tram-cars delivering the ore into the shipping hopper cars of 20 tons' capacity. In them the ore is conveyed to Ashland and dropped through their hoppers into the bins of the ore dock. A second plan of elevating ore is by boom-derricks and trip-buckets, the ore being brought up in these buckets, swung around over a tram-car, and, in some instances, directly over the shipping-car, and dumped upon it. This is mainly confined to open workings however. At the Colby mine a very ingenious arrangement of inclined plane is employed, which is worthy of mention. The ordinary 1-ton mining dump-car is fitted under the framing of its four-wheel truck, with a horizontal iron rod bent upward at either end, so as to permit a ring to slide freely upon it, and yet act as a means of draft from either end. To this ring the hoisting-rope is attached, the rope extending up to the summit of the plane, and passing between two sheaves placed close together, on one of which it rests, and then on a third sheave, which leads the rope at right angles to the plane to a hoisting drum. Beyond the summit of the inclined plane, where these sheaves are placed, there is a short descent to the shipping-platform or wharf, where the railway cars are loaded. In operation, the steam-hoisting drum is started, and the car is raised to the summit, when the steam is shut off, and the inertia of the loaded car carries it over the short piece of level track at the summit; this causes the ring to slide on the bar under the car-track, and, instead of acting as a draft at the front, it now holds back the car from the rear, the speed being controlled by the brake on the engine-drum. Arriving at the shipping-platform, the car dumps, and the hoisting-engine being reversed, raises it to the summit of the plane, when the ring again slides to the front, and the brake controls the descent into the large, open pit.

In the open-pit work, stripping has been done in the ordinary manner, except at the Aurora mine, in Michigan, where a Brown conveyer is employed, the buckets being loaded by laborers, using the pick and shovel, and dumping into small tram-cars running out on to the spoil-bank. At the Montreal mine, in Wisconsin, the stripping is removed by small dump-cars on an inclined plane. Where the ore bodies are as wide as in some of the developed mines, 80 to 120 feet, and the stripping 10 or 15 feet in depth, a steam shovel would appear to be the most economical method of removing such a large quantity of earth, and it is not improbable that similar appliances would work advantageously in the soft ore. Most of the ore in the Gogebic range is so soft that it can be removed with the pick-ax, explosives being employed chiefly to loosen up the mass. This ore could, after being so loosened, be handled in the open pits by steam shovels, for the ore as dug can be loaded directly on the cars, it being clean, and requiring no washing or sorting. It may be asserted, as a rule, that, where the ore lies in large masses, but little of it will require sorting, and, even in mining, the proportion of lean ore, or foreign material, is insignificant, except near the confining walls, or where "horses" of rock occur. These "horses" are not uncommon, and are found in most of the mines now extensively opened, but they are by no means causes of discouragement; for already, after passing through a "horse," ore has been found below it, or the projection of a "horse" into the ore body has apparently forced the ore in front of it. In driving the slope for the Germania mine, a body of ore was struck close to the surface; but, after passing through this, a "horse" of chloritic slate, or as it is termed in the Gogebic Iron Range, "soap-rock," was encountered for 40 feet, when ore was again found, and, when visited, the slope was down 90 feet in this ore body, which was increasing in width as the depth increased. While this cannot be announced as an established fact for the entire region, the widening of the vein occurs so often as to give good reason for the belief of many that generally the ore body increases in width the deeper the excavations are carried. Another instance of a "horse" is in what is claimed to be the north vein of the Colby mine. Here the "soap-rock" pushes in from the hanging wall, and the ore dips under the apparently receding foot-wall. In most of the open mines these "horses" are noticeable. In one Wisconsin mine, it is claimed that a drill-hole reached ore after passing through but 8 feet of rock. In the underground work of the Ashland mine, in Michigan, a "horse" of "soap-rock" occurred in a favorable location to be used as a large pillar protecting the slope—a more reliable pillar than could be obtained from the softer ore. It is a problem of the future whether, in the mines which become permanent producers, the slopes which have been sunk in the ore will not, as in other districts, have to be abandoned, and vertical shafts through the hanging wall or slopes and gangways in the foot-wall be substituted.

The natural outlet for this region would seem to be *via* lake transportation from Ashland, and, to accommodate the traffic, the Michigan, Lake Shore and Western railroad have built an ore dock 2,100 feet long, with a bin-capacity of over 25,000 tons, and another is in course of construction. A third dock is being erected by the Wisconsin Central railroad for shipping Gogebic ores. The freight to Ashland has been fixed at a uniform rate for all the mines of 80 cents per ton, which may be reduced by competition. In the early part of the season, when lake transportation was low, the ore from the Gogebic range could be carried from the mines to Cleveland for $2 per ton, and, as a consequence, the new district became a large shipper.

Up to November 24, 1886, there had been shipped from the district the following amounts of iron ore:

In 1885,	111,661 tons.
In 1886,	724,617 tons.

No better indication of the growth of our iron-producing capacity need be desired than the fact that, while the prominent mines of Lake Champlain, New Jersey, Cornwall, Pilot Knob, Iron Mountain, &c., have kept up their quota, Pennsylvania, Alabama, Virginia, North Carolina, and Tennessee have largely increased their output, and, in addition to the regular quotas from Menominee and Marquette regions, the notable Vermillion mines of Minnesota, and the Gogebic range have entered the list, but, with all this, we are importing at the rate of 1,000,000 tons of foreign iron ores per annum. The development of a district showing a capacity of producing so large an amount of high-grade ores has interfered considerably with the efforts to work the Canadian mines on an extended scale, and would have probably affected more seriously the older districts had not the increased demand from our blast furnaces furnished a ready market for the output of the mines. At present, the Menominee and Marquette regions have a freight advantage over Gogebic, by reason of shorter distances to markets, and the season for shipments from Escanaba is longer than from any of the Lake Superior ports. The necessity of winter suspension of shipments is a prominent factor in the cost of all of the northern ores, and this suspension is now more severe in the Gogebic and Vermillion mines than of the others.

The largest ore producers in the Lake Superior region during 1886 were:

Name of mine.			*Gross tons.*
Lake Superior, Marquette	district,		252,483
Colby, Gogebic	"		250,160
Republic, Marquette	"		241,162
Cleveland, "	"		210,204
Chapin, Menominee	"		195,915
Vulcan, "	"		143,312
Champion, Marquette	"		130,095
Norrie, Gogebic	"		110,715
Minnesota Iron Co., Vermillion	"	(several mines,)	304,396
			1,838,442

The aggregate being more than half of the entire output of the

Lake Superior mines in 1886, which demonstrates that the big mines are the exception.

The accompanying map has been prepared to show the iron ore mining districts tributary to Lake Superior, and their shipping ports. The Menominee range ships all of its ore, which is handled in boats from Escanaba. The Marquette range divides its shipments between Escanaba and Marquette, but some ore has been sent west to L'Anse, and some goes east to St. Ignace. The Gogebic Iron Range has Ashland for its shipping port, and the Vermillion district finds an outlet from Two Harbors. The large and convenient docks, with ore pockets, which have been constructed at these ports, give a cheap and expeditious method of loading vessels with ore.

For great prominence, the names of the district and the shipping ports (except St. Ignace, which is not shown on the map,) are underscored.

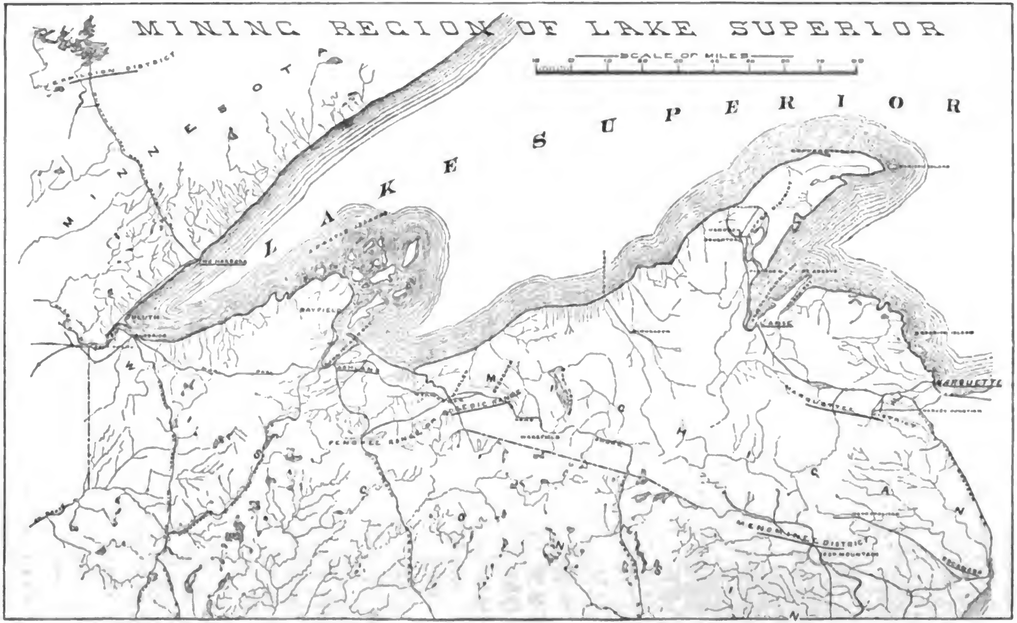
The *Marquette Mining Journal* exhibits the present relative importance of the shipping ports by the following table, which exhibits in gross tons the total lake shipments of iron ore from the mines of the Marquette, Menominee, Gogebic, and Vermillion ranges for the current season, together with the shipments from the same ports last year.

NAME OF PORT.	1886.	1885.
Marquette,	851,986	750,047
Escanaba,	1,538,821	1,219,777
L'Anse,*	. . . . . .	20,027
St. Ignace,	74,590	93,588
Ashland, Wisconsin,	721,983	119,563
Two Harbors, Minnesota,	304,396	225,484
	3,491,776	2,428,486

***Not an ore-shipping port this year.**

The gain over the shipments last season being 1,063,290 gross tons.

It will be noted that the figures for the Gogebic iron range does not correspond with these given above, but the table does not include all rail shipments.


MINING REGION OF LAKE SUPERIOR
SCALE OF MILES
LAKE SUPERIOR
MINNESOTA
WISCONSIN
MICHIGAN
VERMILION DISTRICT
TWO HARBORS
DULUTH
BAYFIELD
ASHLAND
PENOKEE RANGE
GOGEBIC RANGE
L'ANSE
MARQUETTE
MARQUETTE DISTRICT
MENOMINEE DISTRICT
IRON MOUNTAIN
ESCANABA

The Journal.

During the season of depression in business which now appears to be of the past, the absence of funds encouraged a diminution of expenses, which was in part secured by restricting the issues of the JOURNAL until such time as the Association could meet.

The report of the Secretary was very fully considered and discussed, and the results of such discussion are given in the minutes of the annual meeting. The suggestion to discontinue the JOURNAL met with decided opposition, and its value was extolled probably beyond its merit; but the result was a determination to pay all debts of the Association and secure for the JOURNAL income sufficient to advance it.

This determination, and also the policy of making the officers more permanent, has met with approval, and immediately following the meeting the *Iron Age* editorially remarked:

"The annual meeting of the United States Association of Charcoal Iron Workers, held in Philadelphia, was pleasant and profitable, and a discussion following a somewhat unsatisfactory financial report led to some useful conclusions. Among other things, it was decided that the custom of rotation in office, leading to the election of a new President and the reconstruction of the Board of Managers every year, is a mistake. * * * This is wise and practical. Rotation in office for the sake of complimenting gentlemen has wrecked more than one promising technical society. It makes the Secretary the sole responsible officer, and unless he chances to be a very discreet person he is very apt to find in the course of a few years that he and his office are all that remains of the society. The United States Association of Charcoal Iron Workers is much too important a body to go down under a debt of a few hundred dollars. It occupies a place among the technical societies which is peculiarly and exclusively its own. The manufacture of charcoal iron is an industry which depends for profitable existence upon the closest and most intelligent study of all the conditions affecting quality and cost of product. Coke and anthracite irons have so encroached upon what was once regarded as its exclusive field of utility, that it can only hold its own in the competition when made under the most favorable conditions. This branch of iron-making has comparatively little literature other than that which the present Association has created or collected through its well-conducted JOURNAL, and if this modestly useful publication was abandoned, it is doubtful if the great technical societies or the technical press could or would give the charcoal iron industry any attention. These facts are fully appreciated by the membership of the Charcoal Iron Association. Under the new system adopted at the Philadelphia meeting it is likely to have an important career of increasing usefulness. The members can well afford to pay all the costs of carrying out the work outlined for the newly-elected managers, since if done with the intelligence and thoroughness of which the secretary is capable, if properly sustained and seconded, it will be worth thousands of dollars to those whose capital is invested in charcoal furnaces and bloomaries."

We have seldom taken space for the repetition of compliments to the JOURNAL; but, in this case, we feel that the sentiment expressed by the leading iron-trade paper of the country is worthy of being brought to the attention of our readers. We know that the JOURNAL can be, and has been, of great money-value to members of the United States Association of Charcoal Iron Workers as well as others; and this value can be augmented if a fund is always available to secure instructive matter for its pages. We know, too, that others outside of the charcoal iron producers hold the JOURNAL in high esteem, and that the leading metallurgists of foreign countries do not hesitate to commend it.

There, therefore, appears no reason for its abandonment; but, on the contrary, it should advance, and be able to broaden its scope, and discuss process and products of all branches of iron manufacture. The editor has been desirous, for some time, to carry out several plans which would largely augment the interest of the JOURNAL, but the limited funds at command have prevented this.

We would ask each reader whether he desires the JOURNAL to continue and to advance. If so, we wish his hearty coöperation to secure this end; and that assistance can be easily given.

What are needed most are an increased circulation, a greater amount of advertising, and more freedom of communicating results obtained. If each reader will feel that he has something of interest and value to give to the readers of the JOURNAL, and will prepare the data for publication, he can help to accomplish all of the points above enumerated. Short items, giving results of actual practice, peculiarities which are noted at various works, the composition, uses, and costs of obtaining or producing iron ores, pig-iron, blooms, bars, plates, etc., or results obtained in the production or use of various fuels, will make our publication of greater value to its readers, and naturally augment its circulation. Increased circulation will add to its usefulness as an advertising medium. We shall not beg for the support of the JOURNAL; if it is worth being sustained, we shall expect evidences of its appreciation; if it is not worthy of being continued, the sooner it is so recognized the better.

The editing of the JOURNAL is not a matter of profit, but one of hearty interest and a desire to advance the Association and its publication. If cordially sustained, the labor will be a pleasure; but if coöperation is not given, interest in the work must flag, and the editor's time would be employed to better advantage elsewhere.

All that is required of our readers is a unity of purpose, to add to the value of the JOURNAL, by data for publication, to present the claims of the JOURNAL personally to those who would be benefited by its contents, or whose trade might be increased by the use of its advertising pages.

Sample copies will be sent out at request of our readers, if they will add their personal indorsement of the publication.

* * *

NAPHTHALENE, as a wood preservative, is now largely used in Scotland, its action being to destroy all albuminoid compounds in the wood, leaving it dry and clean to handle, and with only a faint aromatic smell. The naphthalene is melted in a vessel capable of being tightly sealed, and the wood is laid in it until experience shows that the saturation is complete. The temperature at which timber is treated is kept as low as possible, so as not to injure the fiber.

The Manufacture of Charcoal in Vermont.

The following statements are given by the Department of Agriculture concerning charcoal manufacture in the Green Mountains: "The walls of the kilns are from 25 to 30 feet in diameter, 12 feet high to the crown, and about 7 feet crown, with a circular opening in the crown of 5 feet diameter The only other opening, except the vents, is the door, which is closed by a plate of No. 8 iron. The floor is of clay and well tamped, and the foundations are thoroughly grouted before the structure is commenced, as the kilns expand with the heat and contract while cooling. There are three tiers of vents or openings the size of a brick left in the walls for the purpose of drawing the fire back and forth—120 vents to each kiln—and they are called "waist, knee, and ankle vents." In preparing a kiln for firing, a foundation of logs is first laid upon and covering the floor, except a fire arch from the door to the center. Then the logs are piled as above described, until the kiln is full, when the center is filled with kindling and the pile is ready for firing. A rag saturated with kerosene is attached to a pole, and, being lighted, is thrust under the fire arch to the center, igniting the soft kindling; the door is closed and hermetically sealed, the thimble or iron circular plate placed over the opening at the top, and for from 10 to 12 days the process of charring goes on, being regulated by the vents around the base of the kiln. It is necessary that the fire should begin at the top and burn downward, and for this purpose two openings are left in the thimble at the top, each of which is easily covered with a brick. These are left open or closed as emergency requires, and the vents are opened as needed to draw the fire downward through the pile. When the wood is sufficiently charred above these vents, which is ascertained by the smoke, or by thrusting a bar into the vents to feel whether it is wood or coal, the knee or middle row of vents and the ankle vents are opened in succession, although the lower vents, as a general thing, are not opened, the collier preferring to burn the lower tiers of logs in another kiln rather than run the risk of overfiring. The kilns have a northern exposure, and when the wind is from that direction great care is necessary not to burn too fast. When it is from other quarters the burning is more regular. Sometimes a sink occurs, which means that the fire is drawn down too rapidly, leaving a middle portion uncharred. This is to be avoided, and can only occur through the carelessness of the collier. After the charring operation is complete the vents are stopped, the body of the kiln is thoroughly whitewashed and the crown covered liberally with coal tar, to make everything air-tight, and the kiln is left for two days to cool off. It is then opened and the coal can be taken out immediately. Thus it requires 13 days at least to burn a kiln, 1 day to fill, 10 to burn, and 2 to cool. The secret of good coal, however, is to take time, and it is preferable to give it 12 days to char."

◆

NORTH CAROLINA WOODS AND TIMBERS.—Over the surface of the State North Carolina, extending upward of 500 miles into the interior, and embracing mountain and valley, hill country and plain, are found every growth from the white pine of Canada to the palmetto of the far South. Along the seaboard are the live oak, the cypress, the juniper. Further inland, intermingled with other growth, there was the long-leaf pine, of which there is, according to the census of 1880, not less than 5,229,000,000 feet of merchantable timber standing in fifteen counties. Yet further west are found the white oak, hickory, white ash, elm, maple, beech, poplar, persimmon, black walnut, yellow pine, and mulberry. Lastly, there is the white pine, cucumber tree, hemlock, black birch, white walnut, chestnut, locust, and lime tree. In the trees here mentioned, only those have been enumerated which give a distinguishing character to the forest of each section.

◆

WOOD OIL is made in Sweden from the refuse of timber cuttings and forest clearings, and from stumps and roots. It cannot well be burned in common lamps on account of the heavy proportions of carbon it contains, but it furnishes a satisfactory light in lamps especially made for it, and in its natural state is claimed as the cheapest of all illuminating oils. Thirty factories produce about 40,000 liters of the oil daily. Turpentine, creosote, acetic acid, charcoal, coal-tar oils, and other useful substances are also obtained from the same materials as is the wood oil.—*Ex.*

M. Langdon
Port Henry
N.Y.

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OF

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JOURNAL
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OF
CHARCOAL IRON WORKERS.

Devoted to discussing and illustrating improvements in iron metallurgy, or in the manufacture of charcoal.

It is mailed, post paid, to each MEMBER and ASSOCIATE of the
UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS,
Or can be obtained for an *Annual Subscription of $5 00.*

Edited by JOHN BIRKINBINE, Secretary,
No. 25 N. E. City Hall Square. (N. Juniper St.),
Philadelphia, Pa.

ARTICLE V.—Constitution of the United States Association of Charcoal Iron Workers.

Any person practically engaged, or interested, by reason or capital invested, in making or using pig-iron or blooms made with charcoal may become a MEMBER of the Association by paying an annual fee of five dollars ($5): *Provided*, That each iron works represented shall pay not less than ten dollars ($10) per annum into the treasury.

Persons not engaged in making or using charcoal pig-iron or blooms may become ASSOCIATES, without the right to vote or hold office, upon the payment of an annual fee of five dollars ($5) each. All fees to be due when the membership is applied for, and thereafter on the first day of October in each year, being in advance.

All communications should be addressed to the Secretary of the Association.

The British Jubilee and the Iron Trade.

Sir Lowthian Bell has contributed a most interesting chapter to the Jubilee publication, "The Reign of Queen Victoria," which bears for its title "The iron trade and its allied industries."

There is so much of value in the paper that we would gladly publish it entire if space permitted, but we can give excerpts only and have endeavored to present those which would most likely interest the readers of the JOURNAL. Much of the matter omitted consists of historical data and statistical information, of which we present some summaries or generalizations, but in some instances the details are considered of sufficient general value to be quoted fully. We would invite special attention to the concise and instructive discussion of the various methods of iron and steel manufacture, a condensed treatise on iron metallurgy, which will be appreciated after perusal, and which presents in a popular form many facts upon which knowledge is often desired. Mr. Bell's statement of the labor demanded to reduce the metal to various forms is of great interest, and his closing tribute to the value of science as an ally to practical knowledge is a neat *finale* for a notable contribution to the literature of iron manufacture.

"In the middle of the last century the manufacture of iron in Great Britain was all but entirely extinguished. Had this calamity not been averted, the reign of Queen Victoria, instead of having been marked by the progress which has pre-eminently distinguished it, might not have greatly differed from the reign of Queen Elizabeth. * * *

"Fifty years ago the quantity of crude or pig iron produced in Great Britain was about 1,120,000 tons. Of this about 235,000 tons was required for the various articles sent out of the country either in the form of the raw or of the manufactured metal. The balance, added to 25,000 tons of imports, makes a total of something like 910,000 tons, which represented the consumption of the inhabitants of the British Isles for 1837. Taking their population to have been 26,000,000, we have about 78 lbs. of pig iron used for each inhabitant during the year in question.

"The foreign iron imported consisted chiefly of malleable bars of superior quality, made exclusively by means of charcoal. It was used principally in the manufacture of steel for cutlery, &c.—an art in which Sheffield during the last two or three hundred years has achieved a world-wide reputation. * * *

"Our home consumption, instead of remaining at 78 lbs. per head of our population, at which it stood fifty years ago, is now nearly 290 pounds. To meet these additional demands, the annual production of pig iron in Great Britain rose from a little above 1,100-000 tons in 1837 to about 8,500,000 in 1882. * *

"Approximately the two rows of figures below will give a pretty fair idea of the growth of the world's make of pig iron between 1837 and 1883, which latter year has never yet been surpassed.

	Tons.	*Tons.*
United Kingdom,	1,120,000	8,500,000
United States of America,	300,000	4,600,000
Other nations of the world,	1,330,000	7,900,000
Total,	2,750,000	21,000,000

Table showing Average Selling Prices of Ordinary Pig Iron for Fifty Years, over Periods of Five Years.

Period ending,	1841	1846	1851	1856	1861	1866	1871	1876	1881	1886
Price per ton,	*s. d.* 77 0	*s. d.* 63 6	*s. d.* 51 7	*s. d.* 54 11	*s. d.* 50 6	*s. d.* 46 8	*s. d.* 46 9	*s. d.* 75 11	*s. d.* 43 3	*s. d.* 35 2
*Equivalent to,	$18 63	$15 38	$12 48	$13 09	$12 22	$11 29	$11 32	$18 37	$10 47	$7 74

*The approximate American equivalents are given for a clearer comparison.—ED.

"Owing to great irregularities in the demand, it is not in the nature of things that violent fluctuations of values should not occasionally occur in an article like pig iron. This happened in 1845, and again in 1873, when that made in Scotland was sold at 5*l.* 10*s.* in the former and at 7*l.* 5*s.* in the latter year. Other descriptions of iron were correspondingly affected during the years in question.

"It is evident, however, that the figures given above indicate, on the whole, a continuous decline since 1837 in the price at which pig iron could be purchased; indeed, during the last months of 1886, Cleveland metal was bought at 6*s.* per ton below the named average price of the year. [viz: $7 00.—ED.]

"It must not be inferred from what has preceded that the reduction in the market price of pig iron was always a consequence of a diminution in the cost of manufacturing it. A sudden increase in the demand has, from time to time, given rise to an extension in the productive powers not only of our own but of other nations. On this demand subsiding, as has happened at various periods in the history of the trade, the powers of supply exceeded the requirements. During the eight years ending 1879 the make of the world fluctuated between 13,439,000 tons and 14,689,000 tons, the average of the whole being 13,950,000. The make was forced up to 18,077,000 tons in 1880, and reached 21,063,000 tons in 1883. This was in excess of what was needed, and consequently stocks, which in the United Kingdom in a healthy state of trade averaged about 500,000 tons, run up to 1,809,000 tons in 1884. Hence the low prices which have prevailed for the last few years.

"The circumstances which originally determined the site of our iron works have undergone considerable changes in recent times. A century and a half ago the position of the ore was the chief guide in the selection, because it was rare that woods to supply the charcoal and water to furnish the power were at any great distance from the intended mine. The county of Sussex affords a case in point, until there, as well as in other localities, the exhaustion of the forests reduced the smelters to great straits for want of fuel. It was the dearth of charcoal that threatened the existence of the British iron trade in 1740, when the annual make fell to 17,350 tons. From this fate it was rescued by the perseverance of Abraham Darby, who succeeded, where Dud Dudley had failed about a century before, in smelting with pit-coal.

"One hundred years ago Great Britain produced 68,300 tons of pig iron, of which 53,800 tons was made with coked pit-coal. For this quantity 85 blast-furnaces were employed to do the work now capable of being performed by three furnaces of modern construction.

"Water-power, used for driving the blowing and other machinery needed in the process, was liable to interruption from frosts in winter and droughts in summer. From this state of dependence on the seasons, the steam engine of James Watt afforded a perfect relief towards the end of last century.

"Darby's labors and those of Watt had the effect of transferring the blast-furnace from woodland districts to the vicinity of the coal-pits, where, in many cases, the clay ironstone of the carboniferous formation, as well as the fuel, could be had at a moderate price.

"Such was the position of the iron trade about the time at which the present history commences, when less than 1,250,000 tons of pig iron represented the make of the kingdom for the year 1839. It was produced at the average rate of 64 tons per week from each furnace." * * *

After detailing the necessity for and the growth of railway transportation, the author states that "these improvements, the rapid generation of steam being the most important, have enabled engineering science to compress within the very compact space of a railway engine, machinery equivalent to 600 to 700 horse-power.

"In 1834, or nearly ten years after the opening of the Stockton and Darlington Railway—the first public undertaking of the kind in the world—its passenger train consisted of a single carriage drawn by one horse. In it an average of 14 persons were conveyed on each journey, 950 being the total weekly number. Out of this germ has grown an institution on which, in the United Kingdom alone, has been transported in one year nearly 700,000,000 human beings, 190,000,000 tons of merchandise, and close to 80,000,000 tons of minerals." * * *

"Following a geological and commercial discussion of the Cleveland district, Mr. Bell states that 'for many years past the mines of Cumberland and Lancashire have produced considerable quantities of an ore containing 55 per cent. of iron, instead of 30 and 32, like that of Cleveland. In 1855, according to the Government returns, the output was 537,616 tons, but this was almost entirely smelted in furnaces at a distance, principally in South Wales and Staffordshire. The total make of pig iron during the year in question, produced at home, was only 16,000 tons. Railway communication with the east coast, soon after 1855, afforded an unlimited supply of fuel, which raised (in 1884) the weight of pig iron made to 1,561,000 tons, and the quantity of ore worked to 2,595,000 tons. * * *

"In 1828 the total make of Scotch pig iron did not exceed 30,000 tons. This was a memorable year for the iron industry of Scotland, for during it Neilson patented his discovery of the hot-blast, by means of which, and the extended use of Black-band, Scotland rose rapidly to the first rank as a producer of the cheapest made pig iron in the world. In 1839 the output was nearly 200,000 tons, from which figure it steadily advanced until 1860, in which year it nearly touched 1,000,000 tons. Ten years afterward the make almost reached 1,250,000 tons, a quantity which has never been exceeded. On the contrary, since 1870, the make has been on the decline, so that it stands now just at about the same point as it was in 1860. This change in the fortunes of the Scotch iron trade is partly due to the more cheaply wrought Black-band being exhausted, and partly to the great competition offered by the large extension in the make of Cleveland pig iron.

"Wales, including Monmouthshire, has always occupied a somewhat peculiar position as an iron producing locality In its best days there was rarely raised above one half the ore required for the pig iron produced in this part of the kingdom. The deficiency was made up chiefly by importations from Cumberland, Lancashire, and the Forest of Dean, assisted by the forge and mill scoria from the malleable iron works on the spot. The erection of malleable iron works in Cleveland, and particularly of rail mills, was speedily felt in Wales. In consequence, the native ironstone raised in 1865 was very little more than one fourth of what it was in 1855, viz: 485,000 tons, instead of 1,665,520 tons. In the course of time, Bessemer steel began to be somewhat extensively introduced as a material for rail making, and this branch was gradually extended in the Principality. With this extension, the ore raised in Wales declined until it may now be regarded as an abandoned industry. for in 1884 the produce of the native mines was only 95,000 tons.

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"Fortunately for Wales, a cheap supply of ore can now be obtained from foreign mines. chiefly from these near Bilbao in Spain. In 1870 the total quantity of this mineral imported into the United Kingdom was 208,000 tons; in 1882 this had increased to 3.282.-000 tons, of which the South Wales works are the largest consumers.

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"Having regard to the raw material—bar iron—being brought from Russia and Sweden, it may appear extraordinary to find so very important an industry as that of steel settling itself at Sheffield, nearly sixty miles from Hull which is its natural seaport.

"It is said that foreign iron was first used about three hundred years ago in Sheffield in the manufacture of steel. If so, it is very likely that British iron, made direct from the ore by means of charcoal, was employed before the Sheffield makers began to impor foreign iron, brought in the first instance from Denmark and Spain In either case the existence of woods capable of furnishing char coal, coupled with an extraordinary abundance of water power to drive the tilt hammers, no doubt greatly influenced the choice of this town as a suitable site for the manufacture of steel.

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"In order to describe with sufficient clearness the improvements which have been introduced into the process connected with its manufacture, a few of the properties and modes of producing the three forms of iron will be briefly given.

"Cast iron is the product obtained by smelting the ore in the blast-furnace. It is fusible at moderate temperatures and expands slightly at the moment it becomes solid, two properties which fit it admirably for being run into moulds. It is comparatively brittle when cold, presenting when cooled and broken an open crystaline fracture. The metal owes these qualities chiefly to a small quantity of carbon absorbed from the fuel during the smelting process. Besides carbon, pig iron always contains silicon, generally phosphorus, and usually minute quantities of other substances.

"The blast furnace is supposed to date from the fifteenth century; by whom and where invented is not exactly known. There is however, no doubt that it was the gradual development of a furnace, two or three feet high, in which wrought iron was produced direct from the ore. Long before this history commences, its dimensions had reached what was then considered a point of finality; hence its performance had, for some time, not been marked by any substantial improvement. It is true that in 1828 Neilson made known the fact that heating the blast to 600° F., by passing it through hot iron pipes before it enters the furnace, greatly reduced the quantity of fuel required to produce a given weight of pig iron.

"It was maintained that at works in Scotland where, previously to the introduction of Neilson's system, eight tons of coal had to be consumed per ton of metal produced, the weight required after its application was reduced to two and a quarter tons or thereabouts. It is, however, now well known that the actual saving due to heating the air did not amount to one-third of what was claimed for it, the remainder being the result of other changes introduced at the same time. Into these, however, there is not space to enter here. So late as 1837 the value of this invention was far from being generally recognized, and a large proportion of the pig iron still continued to be made with cold air. This plan was gradually superseded by the hot-blast, by which the weekly production of the blast furnaces rose from less than 100 tons to 150, and in some cases to 200 tons, with a consumption of something like two and three-quarter tons of coal, previously coked—or, including that required for the blowing engine and heating the air, say three and three-quarter tons.* At this figure it stood until the improvements introduced by the Middlesbrough smelters about the year 1863. These consisted in doubling and in some instances in quadrupling, the size of the furnace and in raising the temperature of the blast from 600° to 1,000° F.

The function of the fuel in the blast-furnace has a two-fold character—partly calorific and partly chemical. By the action of the first, fusion of the metal and scoria is performed, and the ore is heated to fit the oxide of iron it contains for the chemical action required to reduce it to the metallic state. This increase of temperature in the ore and its deoxidation are effected by the hot gaseous matters as they rise through the upper zone of the furnace; but the reducing power they exercise is exhausted before complete combustion of the gas takes place. The gas, thus only partially burnt, ignites when it reaches the air, and was the cause of the blazing volume of flame which in former years marked the iron making districts of the country. This gas, still containing combustible matter. is now conducted to the boilers and hot-air stoves. by which an annual saving of about 6,000,000 tons of coal has been made on the pig iron produced in the United Kingdom alone.

"By the increase in the temperature of the air, by utilizing the waste gases and by increasing the size of the furnace, the produce was raised from 200 to 500 or 600 tons per week, and the consumption of coal, all included, was reduced from three and three-quarters to two tons of coal per ton of iron. More recently the air has in some cases been heated in stoves of fire-brick, to 1,200° or 1,500°, but the economy of fuel by this additional temperature has been small compared to that effected by Neilson and, after him, by the Middlesbrough ironmasters. On the other hand, the weekly produce has been improved to the extent of 50 to 100 tons per week by the 200° to 500° in the heat of the blast, got in the manner just described. Where very rich ores are treated, as in the United States, as much as 60,000 tons a year, or even more than this quantity, has been run from one furnace, part of which extraordinary make is no doubt due to the use of this more highly heated air.*

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*This was the quantity of fuel required to smelt such ore as that of the Cleveland district. In the case of richer ores, such as the Scotch Black-band, &c., the consumption was something less than the weight just named.

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"A passing allusion was made to an ancient mode of obtaining wrought iron direct from the ore in a low hearth, known as a Catalan fire. This plan had a recommendation of affording a purer iron than could be obtained by the blast-furnace, followed by the subsequent process known as that of puddling, and it further appeared to possess the additional advantage of simplicity. Many trials, in consequence, have been undertaken to reinstate a nearly obsolete practice, although it had been displaced very many years ago by the blast-furnace, when the latter was greatly inferior in point of efficiency to the furnaces of the present day. Eventually all the attempts have been abandoned, and the blast-furnace bids fair to remain for all time an indispensable implement in the manufacture of iron.

"Cast iron, however valuable for being run into moulds, is useless where great strength and malleability are required. To obtain a material having these properties, it is necessary to expel those substances which have entered into combination with the metal during the smelting of the ore. At first this separation was carried out in a Lancashire fire, as it is called, similar in dimensions and form to that used for obtaining malleable iron direct from the ore. In it the pig iron was melted with charcoal or coke, the combustion being maintained by a current of compressed air. After fusion the blast was continued, when, by its penetrating the molten iron, the carbon and most of the silicon and phosphorus were expelled, and the result was a spongy mass of wrought iron. The process is an expensive one in fuel, labour, and waste of metal, but the product obtained was one of such quality that it continues to be the method employed for making the highly esteemed bars imported into this country from Russia and Sweden.

"Such was the method of obtaining wrought iron when Richard Cort, a native of England, invented the puddling furnace. In it the pig iron was melted, after which the workman stirs up the liquid metal to expose it to the action of the fire and of the oxide of iron which is always present. As the carbon, &c., are removed the malleable iron appears in the form of granules, which the puddler collects by means of his tools into four or five separate pieces known as puddle balls. Each of these weighs about one hundred weight, and, after being placed under a steam hammer, it is rolled into a rough bar of different dimensions according to the purpose for which it is intended. Six charges or thereabouts constitute a day's work for two men, and the weight obtained is about 25 cwts., produced by the combustion of about the same quantity of coal· The puddling furnace, afterwards somewhat modified, continued from the latter part of the last to the middle of the present century to be the instrument by which, practically, all the malleable iron in the world was eventually made. We will soon see in these pages that this office is no longer exclusively performed by the furnace of Cort; indeed there are not wanting those who foretell that the time is approaching when it will disappear from our forges. Whatever the future may bring, let it not be forgotten that in the puddling furnace we have had a means of producing malleable iron sufficiently good and sufficiently cheap to have achieved those industrial triumphs which have been dependent on this metal for their success.

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*Since writing the above, the author has been informed by his friend, Mr. Andrew Carnegie, that the furnace F at the Edgar Thomson Steel Works, near Pittsburgh, U. S. A., made in four weeks 7,577 ton of 2,240 lbs.

"Before proceeding to say a few words on the nature of steel, the reader may be reminded of the welding power possessed by wrought iron, by virtue of which rare property two pieces, on being suitably heated, may be joined together. This union is so complete, when well done, that the point of junction is as strong as any other portion of the bar.

"If to the wrought iron obtained from pig iron in the manner described, a small portion of the carbon is restored, we have steel varying in hardness according to the extent of such restoration. Hardness and fusibility are promoted by additions to the carbon, softness and power of welding by its partial withdrawal. Steels of certain composition vary in the degree to which they are capable of receiving the valuable property of *temper*. By this is meant the power they possess of being hardened to different degrees by being heated to different temperatures and suddenly cooled. It is this faculty which enables cutlery and edged tools of steel to receive and retain their sharpness beyond that of any material with which we are acquainted. Steel also owes its great and enduring elasticity to its tempering, so that the hair-spring of a chronometer, by which its time keeping is regulated, will make millions upon millions of oscillations without its powers of resilience being sensibly impaired.

"In the matter of strength, cast iron is the weakest of all the forms of the metal; wrought iron is much stronger, but it is steel which is capable of bearing the heaviest load without fracture. The following figures represent the breaking weight in tons, when hung at one end, of a bar having a sectional area of one inch:

Cast iron.	Wrought iron.	Steel.
6 to 14 tons.	20 to 30 tons.	28 to 60 tons.

"The methods of making steel are so numerous that any reference to even some of the principal ones must be very brief.

"A simple plan consisted in exposing the molten cast iron in a low fire under the same conditions as when wrought iron is made in the manner still pursued in Sweden and Russia. Such exposure was arrested when the carbon remaining was enough to constitute steel.

"The principal of partial decarburisation has also been applied to the puddling furnace, the product being known as puddled steel.

"Cast and wrought iron were melted together in crucibles, in proportions calculated to give steel of any desired composition as regards carbon.

"For producing an article of the highest class the process known as that of cementation is the one pursued. For this, pig iron made from the purest ores smelted with charcoal is converted into malleable iron in the Lancashire fire, charcoal also being the fuel employed. The product is carefully hammered, and the bars so obtained are exposed to a pretty high temperature for about ten days in fireclay chests filled with charcoal. At the end of that time the iron has absorbed the needful amount of carbon, and the steel thus made is fit for being welded or melted in crucibles to form cast steel. To effect this fusion as much as four tons of coke were required for one ton of steel, but the quantity of fuel now consumed has been much reduced by the use of the Siemen's plan of burning gaseous fuel with heated air.

"The cementation process is also applicable to irons of inferior quality to that referred to above.

"In 1856 a paper was read before the British Association 'On the Manufacture of Iron and Steel without Fuel.' From this communication we learnt that it was possible to obtain several tons of wrought iron in a state of perfect fusion, without the aid of any heat beyond that produced by the combustion of a portion of the pig iron from which it was made. The paper in question was contributed by Henry Bessemer, and the process it described was that now so well known in connection with his name. The difference between the process he described and any of those in previous use lay in the manner in which the air used was introduced into the liquid cast iron. Whenever it had been sought to remove the carbon, &c., from pig by means of compressed air, so as to obtain wrought iron or steel, the current was directed downwards into the melted metal. The bottom of the Bessemer converter as it is called, is perforated by several openings, through which a very much larger volume of air was made to pass upwards through the iron than was possible when the blast was made to descend.

"We have already seen how the old Lancashire fire used for obtaining wrought iron was displaced by the puddling furnace of Cort, in which, by the exhausting labor of two men, about 25 cwts. represented a day's work. For this, a weight of coal equal to that of the iron produced was consumed in the operation. A century later we return to the blast, which is made to perform the mechanical work of the puddler, but with such rapidity that ten or twelve tons of pig are converted in about fifteen minutes.

"Elevation of temperature is a result of quick combustion, and this, in the Bessemer process, is so violent that we have several tons of molten wrought iron obtained without any fuel beyond that required for blowing the air through the liquid mass. It must not, however, be supposed that this result was achieved without many obstacles having been encountered. It was speedily discovered that only pig iron of the purest class, rarely met with in commerce, was capable of being treated successfully in a Bessemer converter. This difficulty was surmounted by Mr. R. F. Mushet discovering that the addition of metallic manganese corrected the defects in iron and steel obtained from the less pure kinds of pig. But, even with this additional precaution, it was found that no metal containing above one part of phosphorus in one thousand was suitable for the new process.

"It unfortunately happened that of the ores found in the United Kingdom a very small proportion only offered a product sufficiently free from phosphorus for making steel. Thus the pig iron got from ironstone of the lias or from the coal formations often contains 1 to 1¾ per cent. of this element, and was, in consequence, quite unfitted for use in the Bessemer converter. By the joint effort of several metallurgists* this evil has also been successfully dealt with, by what is now well known as the *Basic process*, in which the phosphorus is transferred during the act of conversion from the iron, by means of lime, to the slag which is formed.

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"We have in the liassic ironstone phosphorus assimulated during life by a low type of animal beings, at an early period of the history of our planet. Countless millions of these were buried in the torrents of ferruginous mud brought down to the sea, which served for their feeding ground. The phosphorus they derived from its waters is now reappearing in the pig iron obtained from the sedimentary iron ore in which the remains of these prehistoric animals were embalmed. Here it has been a source of infinite trouble to our iron manufacturers, for which the basic process has provided a remedy. In addition, there is now a further prospect of relief by the promise that the phosphorus, instead of being a source of loss, will, in the slag to which it has been transferred in the basic process, be useful as a fertilizer of the soil.

"The molten steel obtained from a Bessemer converter is poured into an iron mould, from which it is removed after being sufficiently solidified. While still red-hot it is usually taken direct to a furnace, where it remains a short time, and is then rolled into a rail or other object for which it may be required. Indeed, for some articles, the heat evolved during the active combustion in the converter is sufficient to permit the steel being roiled into the finished bar direct from the ingot mouid. Thus, instead of the repeated heating and cooling, involving use of coal and waste of iron, in the older method of conversion by puddling, the pig is brought in the molten state from the blast furnace to the new converter. It is there blown into steel, and, with at most one reheating, we have

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***Mr. Thomas, who was associated with Mr. Gilbert, Mr. Snelus, Mr. Windsor Richards, and Mr. Martin, received the Bessemer Gold Medal from the Iron and Steel Institute for the services rendered to this important invention.**

the finished bar, greatly superior in strength and durability to the ordinary puddled iron.

"Taking rails, for the purpose of comparing the economy of the two modes of manufacture, it may be assumed that the labor in the Bessemer process is very little more than one-fourth, and the coal consumed does not exceed one-fifth of that required for the production of the ordinary wrought iron.

"It is only right to observe that the economy effected by the Bessemer process itself has been largely assisted by improvements in the machinery devised in later years. Hot ingots weighing a ton each, and vessels containing ten tons or more of molten steel, are moved with ease and expedition by hydraulic power. *

"A railway bar 130 feet in length is drawn out from an ingot 6 feet long in three and a half minutes. * * *

"Such is the power and completeness of the rolling machinery now in use that there are instances of nearly 400 tons of rails having been turned out in twelve hours by one mill.

"Fifty years ago the largest iron boiler plates which could be rolled measured 9 feet by 3 feet, and weighed 5 to 7 cwts. Now iron of this description is turned out 13 feet by 10 feet, weighing 15 to 18 cwts. Still more striking is the present power of producing armour plates for protecting the sides of our war steamers. These are made as large as the thin plates just mentioned, but, instead of about three-eighths of an inch, they measure 19 inches in thickness, and weigh when finished 43 tons. To manufacture such plates as these, furnaces to heat masses of metal, machinery to move them to the rolling mill, and rolls to extend them have to be sufficiently powerful to deal with 54 tons, which is the weight of the rough block of iron or steel required to give a finished armour plate of 43 tons.

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"There are to be found certain authorities who declare that the Bessemer process, wonderfully rapid as is its action, is now so completely under control that the product is almost, if not quite, equal in quality to the finest descriptions of cutlery steel. Against this assertion we have the fact that a larger quantity than ever of steel is produced at Sheffield by the old and more costly method of cementation, in which expensive malleable iron made exclusively by charcoal continues to be the material employed.

"There are others who are equally confident that, for purposes where a material of a perfectly uniform quality is required, the less expeditious process known as the 'open hearth' must be employed. This operation is conducted in a reverberatory furnace devised by Messrs. Siemens Brothers, in which, by the combustion of heated gaseous fuel burnt with heated air, a temperature sufficiently intense to fuse malleable iron can be excited. The use of steel obtained in this way is growing in its extent. Thus in 1879 there were produced 834,511 tons of Bessemer ingots against 175,000 tons made in the open hearth. In 1885 the quantities were 1,304,127 tons of the former, and 583,918 tons of the latter.

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"There is no doubt that the superior malleability of steel permits its being manipulated with greater ease than is the case with iron. A boiler plate of steel can be readily rolled 35 feet long by 9 feet wide, whereas the chances are that most iron would often exhibit defects in any attempt to produce a plate of these dimensions.

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"If anyone were to venture on the prediction that the manufacture of iron or steel had almost reached the ultimate limit of economy, he would incur the risk of being reminded that the experience in other industries had often proved the rashness of such opinions. In the branch we are considering, the assertion perhaps rests on safer ground than some former prophecies of this kind. Each item in every stage of the process, from smelting the ore to the finished bar, has been very carefully studied, and the actual quantity of heat involved in its accomplishment has been pretty accurately ascertained. In like manner the amount of heat capable of being excited by the combustion of the fuel is now well understood. This, with the knowledge it is believed we possess of the nature of the chemical action of the blast furnace, enables us to calculate the possible margin for any further reduction in the quantity of coal consumed. From this information it has been computed that the margin is only a very small one—probably, at the outside, not exceeding 5 cwt., beginning with the ore and ending with the ton of finished steel. On the other hand, the large production of a Bessemer pit, and the great weight of work turned out by such a rail mill as that described in these pages, have so reduced the cost of labour as to leave little room for much further economy.

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"Reference has been made in the present article to the quantity of pig iron produced in the United Kingdom and in the world at large. When we are told that the weight of the former is 8,250,000 and the latter 21,000,000 tons, few people realize the meaning of those large numbers. It may assist those who desire to form an idea of the dimensions of such masses of metal to be told that the iron made in Great Britain would form a cube of 351 feet on a side, while that of the world at large would be contained in one of 472½ feet. The latter would therefore be equal to a bar, 12 inches square, having a length of 19,996 miles, or if run into a sheet one inch in thickness, it would cover an area of 45½ square miles.

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"As regards the consumption of iron among different nations, all that can be given under this head is the weight of new iron supplied. In addition to this, however, there are large quantities of old metal returned to the works for remanufacture. Leaving this out of the account, and dealing only with the new, we have at all events a standard which will serve us as a comparative test.

"If we assume the population in Europe in 1884 to have been 348,180.000, the annual consumption, according to the journal of the British Iron Trade Association, was supposed to vary among different nations from 23 lbs. to 287.53 lbs. per head—the latter being that of the United Kingdom.

"The 51.152,000 inhabitants of the United States required 270.92 lbs. per head.*

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*In referring to the relative positions, in 1886, of Great Britain and the United States, as pig iron consumers, the *American Manufacturer* lately published the following: "In that year the United States produced 5,683,329 gross tons, imported 361,772 tons, and reduced the stock on hand at the close of 1885 to the extent of 163,808 tons—making a total of 6,208,909 gross tons as the approximate amount consumed in 1886. In the same year Great Britain made 6,870,665 gross tons; but from this must be subtracted 3,389,197 tons that were exported and 139,335 tons that during the year were added to the stock on hand at the close of 1885—leaving a balance of 3,342,133 gross tons as the approximate amount consumed in 1886. The account therefore stands as follows:

	Gross tons.
Pig iron consumed in the United States in 1886,	6,208,909
Pig iron consumed in Great Britain in 1886,	3,342,133
Difference,	2,866,776

ED.

"The population of the British possessions, numbering 11,465,079 persons, exclusive of India, consumed 121.40 lbs. each, while the British-India territories, containing 31 per cent. of the inhabitants of the globe, only used 2.40 lbs. per head. The remainder of Asia, representing 517,161,000 people, managed to live with less than half a pound—*i. e.* .49 lb. per annum.

"South America and its islands, with 45,459,000 persons, used 13.5 lbs. per head; and Egypt, having 5,517,000 inhabitants, required 7.55 lbs. per individual.

"The total population of the world—say, 1,424,680,000 persons—consumed, for the year we are considering (1884), 32.33 lbs per head.

* * * "It has been computed that, for the railroad itself as it exists at the present day in our own country, there has been worked up between 10,000,000 and 11,000,000 tons of pig iron, and for the locomotives, carriages, and wagons about 6,000.000 tons more, together 16,000,000 to 17,000,000 tons.

* * * "To make good the loss of weight due to wear and that incurred in remanufacture on the railways of the United Kingdom, probably about 300,000 tons of pig iron are annually consumed. * * *

"At present the manufacture of iron rails may be regarded as an obsolete industry, but there is every hope that the diminished demand for rails, arising from the greater endurance of steel, may be met by the wooden sleepers on which they are laid being replaced by metal.

* * * "It was only a little before 1830 that William Fairbairn built a few iron canal boats, and not till that year that he launched three small steamers for the coasting trade. The progress of this new industry, however, moved slowly, for it was 1836 or 1837 before he commenced the building of iron vessels as a regular business. Thirteen years after this, viz: in 1850, out of 132,800 tons of shipping built in that year, 120,000 tons continued to be constructed of wood. Soon after this period iron gradually grew in favour, so that in 1882 there was only about the same amount of wooden tonnage constructed that there had been of iron in 1850. In consequence, however, of our extended commerce, assisted by our cheap iron, by the use of the screw-propeller, and by great improvements in our marine engines, the ship owners

of Great Britain have become carriers for almost the whole world. To such an extent has our mercantile fleet increased, that there were launched in the year 1883 no less than 1,116,555 tons of shipping, and the iron consumed in the hulls and machinery during the seven years ending 1884 was close on 4,000,000 tons.

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"To compare wood and steel, Mr. James Laing, of Sunderland, has kindly furnished the writer with the weights of the material used in building the hull of the 'Duncan Dunbar' in 1857. They were as follows:

	Tons.
Iron knees, bolts, pillars, diagonal strappings, &c.,	130
Copper sheathing,	25
Timber of various kinds, finished weight	895
Weight when launched,	1,050

"The weight of a hull of steel of the same external dimensions as the above would be:

	Tons.
Iron used, 45 tons; steel, 500 tons—total,	545
Wood for decks, cabins, &c., tanks, cement, &c.,	175
Weight when launched,	720
Difference,	330

"As a result of this difference of weight, the steel vessel would carry 2,200 tons of deadweight against 1,870 tons capable of being conveyed on the wooden ship. Besides this advantage, the sides of the former ship are so much thinner than the other that it contains 4,000 cubic feet more internal space.

* * * "Mr. John Pender gives 400,000 tons as the weight of the 1,714,000 miles of overhead telegraphic wire of all nations. Roughly speak, this gentleman considers there are in 107,000 miles of submarine cables now in use 200,000 tons of iron.

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"With the demand for wire for telegraphic purposes, its substitution for hempen ropes, its use for fences and other objects, it has been estimated that the weight of iron and steel converted into this form alone is not short of 500,000 tons a year.

* * * "It has been calculated, upon the best data at our command, that in the United Kingdom as much as 500,000 tons of pig iron are consumed in its pipe foundries. Of this quantity one-half is required at home, and the remainder is exported over sea.

* * * "In 1885 the exports from the United Kingdom of tinplates, chiefly for America, was close on 300,000 tons, or nearly three times what it was twelve or fifteen years ago. Before long we may expect the total make of tinplates in the world to reach 500,000 tons a year, which means enough to cover an area of nearly fifty square miles.

"It may be convenient now to close this necessarily imperfect account of the uses to which iron is put, by an approximate estimate of the purposes to which it is applied in the United Kingdom. Five years, ending with 1884, have been selected as being those of the largest makes.

"*Approximate Weight of Pig Iron to produce various Articles consumed in the United Kingdom* (1=1000 *tons*).

	1880	1881	1882	1883	1884
Construction of new railways, ...	131	84	161	66	149
Renewals of old railways, loss in remanufacture, . .	90	90	90	90	90
Additional rolling-stock, new, ...	52	100	40	40	92
Renewals of old rolling-stock, loss in remanufacture,	160	160	160	160	160
Total for railways, ...	433	434	451	356	491
Shipbuilding, ...	390	579	763	860	611
Gas and water pipes, supposed, ...	250	250	250	250	250
Tinplates, supposed, ...	75	75	75	75	75
Architectural works--Machinery for home use, domestic purposes, for telegraphs, for fencing, &c.,	2,097	2,138	1,964	1,981	2,136
	3,245	3,476	3,503	3,522	3,563
Pig iron exported as such, or that required for rails, bars, &c., exported or consumed in Great Britain for machinery for exportation, ...	4,332	4,404	5,002	4,663	4,054
	7,577	7,880	8,505	8,185	7,617

* * * "Considered from the labour point of view in the iron works themselves, we are standing only on the threshhold of any estimate we may attempt to form of its real magnitude. This we only begin to realize when we approach the work shops in which the metal has to be converted into those articles which fit it for actual use.

* * * "Annually there are consumed in the United Kingdom about 300,000 tons of railway-chairs, which are usually sold at about 55*s.* per ton when pig iron costs 40*s.*, leaving thus only 15*s.* for the expense of conversion.*

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*As the following figures are approximations, the shilling (*s.*) may be considered as equivalent to twenty-five cents and the pound (*l.*) to five dollars.—ED.

* * * "The increase of value is about doubled, i. e. gas and water pipes are sold at something like 4 *l.* per ton. Articles like stove-grates used in domestic fireplaces weigh but little, and receive little labour beyond that incurred in running the iron into moulds, and are sold at from three to four times the price of the metal employed; kitchen ranges are worth nearly four times the price of the iron entering into their construction.

"For shipbuilding as much as 500,000 tons of wrought iron and steel have been used in one year. If we assume the value to be 2,500,000 *l.*, the mere wages for constructing the hull will amount to something above one-half the cost of the metal used.

* * * "The value of the finished machinery placed in a vessel will probably be about ten times that of the raw materials as received from the ironworks.

"Again, a locomotive engine and its tender costs in the market about 60 *l.* per ton, which is about nine times the value of the metal used in its construction.

* * * * *

"Common needles, such as are exported to China, are made from Bessemer steel wire, costing the manufacturer about 60 *l.* per ton, the steel billets from which this wire is produced being worth about 4 *l.* to 5 *l.* The finished article sells for 260 *l.* The delicate instruments used for fine work are made from wire costing 2 *s.* 6 *d.* per lb., or more than the needle which suffices for the Chinese, while the needle for home use sells at 5,600 *l.* per ton. In the manufacture of fish-hooks, the wire used for the production of the finest costs 336 *l.* per ton, while the hooks themselves sell at the rate of 14,000 *l.* to 15,000 *l.* per ton.

"Probably the most expensive form in which iron is sold is for the steel hair-springs in watches and timepieces. It is needless to say the consumption is very limited in its amount, for it would require nearly forty millions of the former to weigh one ton. The retail value of this quantity would be about 400,000 *l.*, or above three times the price of gold. The main-springs of timekeepers are a coarse and inexpensive article compared with the more delicate instrument just named, for they only bring about 6,000 *l.* per ton.

* * * * *

"The figures given in these pages, indeed, countenance the belief that any future extension of the demand for iron in this country will be chiefly that required by any increase that may take place in our population. On the other hand, foreign nations are constantly adding to their demands for a metal in constant requisition by people who are following our example in extending home industries. This want of iron was formerly, and continues to be, largely addressed to the ironmasters of Great Britain; but while the world's requirements have largely increased in late years, the quantity exported from this country, as may be seen in the table recently given, has declined. This arises from the greatly increased production in the United States, in France, and in Germany as compared with our own. Thus between 1870 and 1883 the make of pig iron in Great Britain rose from 5,963,000 to 8,529,000 tons, while that of all other nations, from 5,602,000 tons in the former year became 12,534,000 tons in the latter. This means that while our increase was 43 per cent., that in other countries amounted to 223 per cent.

"It is no secret that this greater activity in the foreign iron trade has been mainly promoted by the heavy duties directed against the importation of British iron. It is better that it should be so than that the decline of our export trade should arise from nature having been less lavish in her gifts to us than she has been elsewhere, or that we are less skillful in utilizing our opportunities than our foreign competitors are in turning theirs to good account. As much as this, indeed, has been said upon some occasions in comparing the progress of the iron manufacture in Great Britain with that of other countries, but the record of the origin of the improvements contained in these pages gives no countenance to such an opinion.

"When a branch of industry has reached the position claimed here for the iron trade, its votaries have no alternative but to turn to the lessons of science for inspiration Mr. Huxley, one of our greatest living teachers, has recently warned us of the 'dangers of dropping astern for want of the education which is obtained elsewhere in the higher branches of industry and of commerce.' The captains who led the forces in the iron trade were formerly as open to criticism in this respect as those of any other company in the industrial army. It is, indeed, well within the recollection of the writer when, to use the learned professor's words, the ironmasters 'looked askance at science.' The figurative 'flirtation' he speaks of between science and art already approaches to an 'intimacy,' which bids fair to ripen into a firm alliance. If so, then in any fresh departure from the old trodden ways we may hope to see our iron manufacturers advancing side by side with those of any other nation.

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IN an obituary notice of the late Ben: Perley Poore, the *Chicago Inter-Ocean* says: "Major Poore possessed in his library, he believed, every work on agriculture that had ever been published in this country, besides many from abroad. He was a skilled agriculturist, as was his father before him, who took the premium of $500 offered by the Massachusetts Agricultural Society for the best cultivated farm. Major Poore gained from the same association the prize of $1,000 for the best growth of forest trees. He pointed with no little pride to this grove, twenty acres in extent, of oak, hickory, chestnut, locust and evergreen, every one planted by his own hand.

The homestead of Indian Hill contains over two hundred acres, with a hundred acres in woodlands. These last embrace sixteen varieties of oaks, all that will grow in this latitude, including the "royal oak," grown from acorns from the tree at Boscobel, in which Charles II hid himself after the battle of Worcester."

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PRODUCTION OF IRON AND STEEL IN SWEDEN, METRIC TONS.

	1882.	1883.	1884.	1885.
Iron ore,	892,863	885,124	909,553	873,362
Charcoal pig-iron,	398,945	422,627	430,534	464,737
Bar iron and rods,	259,462	255,853	264,944	257,369
Bessemer iron and steel,	47,358	50,878	53,123	52,021
Martin iron and steel,	13,405	16,800	19,354	26,743
Other kinds of steel,	1,430	1,827	1,764	1,786
Plates,	15,805	17,439	17,534	16,494
Nails,	8,143	8,197	9,720	10,577
Number of furnaces in blast,	185	191	178	179
Total time for all furnaces in blast, days,	40,157	41,229	49,361	42,460
Average time for furnace in blast, days,	217	216	227	237
Average production per furnace and day,	9.93	10.25	10.67	10.95

For these figures we are indebted to Prof. Rich. Akerman of Stockholm.

Iron Manufacture in Canada.

The increase of duties upon certain forms of iron and steel manufacture lately adopted by the Dominion Parliament, has caused such strong protests from those in Great Britain who have largely supplied the Canadian market, as to bring the subject into greater prominence than otherwise would have been the case. Naturally, governmental action by our neighbor interests us, and will, to a certain extent, affect our trade with the Dominion, and it is probable that such influence will affect the charcoal iron-workers of the United States more promptly than the other branches; for Canada has been a good customer for American car-wheel iron, which has been shipped into the immediate neighborhood of ample forests from which charcoal could be obtained, and close to deposits of iron ore which either were not exploited, or if operated the ore was sent to this country to be smelted. The extent to which the charcoal furnaces of the United States are affected will depend largely upon the ores which are employed, and any new brand must first be tested and earn a reputation before it will supplant others whose good names are of long standing. Nor can the necessary plants be constructed, equipped and put in operation, except after considerable time shall elapse and the effect of the revised tariff must be learned by experience. The former Canadian duty of $2 00 per net ton has been increased to $4 00 per net ton; to which a bounty of $1 50 per ton must be added. Therefore, for the present, the Canadian duty on pig iron is $5 50 per net ton, or $6 16 per gross ton; while the United States duty is $6 72 per gross ton. After two years, the bounty will be reduced to $1 00 per ton, at which rate it will continue for three years more.

That the conditions affecting Canadian iron manufacture may be presented to our readers, the following extracts are taken from the Budget speech, delivered in the Canadian Parliament, May 12, 1887, by Hon. Sir Charles Tupper, Minister of Finance, who treats the subject from a Canadian standpoint. While we will not be expected to endorse the enthusiastic prognostications of a political leader espousing the cause of his government, it is well that we should hear the case presented in the strongest manner. That

Canada abounds in excellent forests is well known, and the efforts made in late years to secure control of some iron ore properties in that country are generally understood. But there are more ore bodies than the Minister of Finance refers to in his speech; one of which is now recalled to us as lying west of Thunder Bay, and exhibiting encouraging indications as to quality, while the analyses are exceptionally good.

Sir Charles Tupper says "there is a field still unoccupied that presents greater possibilities and greater opportunities than any other for developing Canadian industry, and it lies at the very root and foundation of the National Policy in all countries where it has been adopted. I refer to the iron industry. The greatest industry of all in this country, and in all countries where iron and coal are found to abound, we have neglected up to the present hour to do justice to this great Canadian industry. * * *

"In relation to this, the great industry of Canada, the great industry of Great Britain, the great industry of the United States, of Germany, of Belgium; one of the greatest industries of France, and one of the greatest and most important industries of all the great countries that possess iron and coal. We have, down to the present time, ignored that fundamental principle of the application of the system of protection in proportion to the labor involved.

"We have at this moment a bounty of $1 50 a ton on pig iron, and $2 00 a ton duty upon pig iron.† * *

"If there is country in the world to which the iron industry is important, it is Canada, and why? Because we possess the coal and we possess the iron ore and we possess the fluxes; having everything necessary to develop the great iron industry within our borders, and yet down to the present moment we have left almost untouched, this enormous, this almost illimitable field for the extension of our National Policy.

"The national importance of the iron industry is seen at once when we take into consideration the fact that it furnishes the material necessary for agriculture, for commerce, for manufactures, for offense and defence, and for all other manufactures, with scarcely an exception. It becomes, for these reasons, the most important of all the industries of the country. So valuable is it regarded.

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†The Canadian Government employs the net ton (2,000 pounds), as a basis in its custom collections.—ED.

that all nations who have the means of developing that industry, have addressed themselves to that work as one of prime importance.

"The means of developing the iron industry of a country depend, first, upon the possession of the ore; second, upon the possession of the coal or other fuel that is required to utilize it; third, upon the possession of the fluxes, and fourth, upon the proximity of these articles to each other, and of the facilities for transporting the product from the points where it is manufactured to the great centres of the country, where it is to be used as an article of commerce. Canada occupies in this regard a vantage ground over almost every country in the world. England possesses coal and iron ore to an almost illimitable extent; but the House will perhaps be surprised to learn that even England, with all its ore and all its coal, imports from Spain, a thousand miles away, more ore than is required to manufacture the entire production of steel in England. The United States possesses almost unlimited quantities of iron ore and coal; but they have no such advantage as Canada enjoys. Their iron and coal are widely separated from each other—so widely separated that the ores of Wisconsin and the Lake Superior region are sent a thousand miles away to Pittsburgh to the coal area to be manufactured into iron. In the southern States they have coal and iron in close proximity, but with this drawback, that they are over a hundred miles from the seaboard, over which distance the manufactured article has to be transported by rail. France, which has developed a great iron industry, has to import both iron and coal. That country has both ore and coal to some extent, but no less than 35 per cent. of the ore manufactured in France is imported from a long distance. Belgium has plenty of coal, but imports iron ore from Germany. A large amount of iron ore manufactured in Belgium, which has become so powerful a competitor of England in iron, is manufactured from ore imported from Luxembourg; but it sends all the way to Spain for the ore used in the manufacture of Bessemer steel. If these countries, without the advantage of having iron ore and coal in close proximity, can import one or the other a thousand miles and carry on the manufactures of iron, what can Canada do, which has the great advantage of possessing illimitable coal fields and illimitable stores of iron ore in close proximity? England and the United States both form notable examples of what can be done in the development of a great industry by protection. * * *

"The production of pig iron in the world in 1865 was 9,250,000 tons; in 1883 it had gone up to 21,000,000 tons, showing that all that is necessary in order to extend to an unlimited degree the use of iron is to be able to produce it, and showing also that it affords a field for the application of the sound principles of the National Policy that no other industry in the country affords. The result of this policy may be briefly stated that during the last twenty one years, from 1865 to 1885, the increase in the production of pig iron in Great Britain has been 76 per cent. In the United States; 456 per cent.; in Germany, 237 per cent.; France, 64 per cent.; Belgium, 64; Austria and Hungry, 152 per cent. * *

"The time is not long since, when charcoal iron was one of the most important industries in Ontario and Quebec. I have no hesitation in saying that if the protection we have given to cotton and woolen and all other industries of Canada be applied to iron, to-morrow will show what the past history of Canada has shown, that these charcoal iron industries will again be in full blast, and that in Ontario and Quebec they will become most essential and important industries in the future as they were in days gone by. Everybody knows that charcoal iron is the most valuable product of iron; every person knows the increase of value of charcoal iron; every person knows that the great difficulty is the cost of producing it, but there is no country in the world that has such a field for the production of charcoal iron as the Provinces of Quebec and Ontario. You have the ore in illimitable quantity, you have a boundless field for the production of the ore, and you have, running along through the same tract of country, magnificent forests adapted to furnishing the charcoal. At present what are the people obliged to do? Those who go into the wilderness to make a farm have to spend their valuable labor in cutting down the timber, and consuming it on the ground without receiving anything from it. Vivify, give protection to the iron industry, as you have given it to cotton, woolen, and everything else, and what will be the result? It will be, that when a man goes into the forest to make a farm in Ontario or Quebec, the most valuable product under his hand will be that which he has to spend all his labor and capital now in wasting. You will have colonization extended in Ontario and Quebec as nothing else could extend it. The experiments recently made by some of the great lines of railway in the United States have shown, as the result of scientific analysis, that the mode of making the life of a rail infinitely greater than it is, is to have incorporated in the rail a large portion of charcoal iron, and under this recent discovery, there is a field for the development of charcoal iron, that will go far to make it one of the leading industries of Canada. There is at present, as you know, in Ontario, running through a large number of counties and townships, a most valuable deposit of iron ore. A railway has been built, the Central Ontario, over 100 miles long, to carry this ore to Weller's Bay, to be shipped across the lake to Charlotte, Oswego, and other points on the American side. Well, from Oswego and Charlotte on the American side to the anthracite coal field, is only 150 miles, and I say that, under a policy which will give iron the protection we give to everything else in Canada, under the National Policy, you will have the ships that convey the ore to Oswego or to Charlotte, or to any of those places from Kingston, Cobourg and Weller's Bay, bringing back the anthracite coal, and you will have the establishment of blast furnaces at Cobourg, Kingston and Weller's Bay, that will give the iron industry of Ontario a better position than it occupied years ago. * * *

"Now, charcoal iron from bog iron ore was formerly an important industry both in Ontario and in Quebec, and charcoal iron was also made in Carleton, N. B., where to-day, under a policy of fostering this industry in the same way as the cotton and woolen and other industries have been fostered, that blast furnace in Carleton would again be lighted up and would be the foundation of a new and extensive industry in the Province of New Brunswick. * * *

"IMPORTS OF IRON AND STEEL AND MANUFACTURES THEREOF INTO THE DOMINION FOR HOME CONSUMPTION FOR YEARS.

1868,	$6,885,365	1879,	$7,962,295
1869,	7,385,780	1880,	10,128,660
1870,	7,750,867	1881,	12,955,855
1871,	10,808,645	1882,	17,499,488
1872,	15,913,179	1883,	20,080,274
1873,	25,435,020	1884,	14,790,727
1874,	20,700,387	1885,	11,415,713
1875,	18,199,198	1886,	11,053,365
1876,	12,965,117		
1877,	11,082,321	Total,	$253,210,513
1878,	9,398,306		

"We have specular iron ore with 68.33 percentage metallic iron, compact limonite 57.71, fibrous limonite 59.50, red hematite, and also fossiliferous hematite 54.36, and spathic ore with 43.56.* In New Brunswick there is hematite iron ore; in the county of Carleton ore and coal are to be found, also in different districts of that Province. Bog ore in Queen's, Sunbury, York, Charlotte, Restigouche and Northumberland counties, in close proximity to the Inter-Colonial Railway. It is specially applicable to the manufacture of charcoal iron. There are iron ores in Quebec. Magnetic iron ores are found more or less throughout the Laurentian range of mountains along the Ottawa river. At the Hull or Baldwin mines, west of the Gatineau river, the ore analyses 67 per cent. The quantity is estimated at 100,000,000 tons. The Haycock mine ore ranges from 64 to 68 per cent. metal. Bristol mine 58 per cent. iron. In Three rivers and Drummondville there is both bog and iron ore in abundance, and unlimited timber for making charcoal In the Eastern District of Ontario, between Lake Ontario and the Ottawa river, there is magnetic iron in abundance. * *

"There is plenty of timber all through this district. I had a conversation with a surveyor who had explored these lines for a hundred of miles through these districts, and away up 130 miles further, to the inter-section of the Canadian Pacific railway, and I was assured that not only was there an unlimited quantity of iron through that district, but that the forests along that line of communication could not be surpassed in any country in the world for the production of charcoal. * * * *

"You have not only 50,000 square miles of this lignite and bituminous coal in the great North-West, to furnish enormous quantities of fuel for generations to come, but you have on Big Island, in Lake Winnipeg, a valuable deposit of iron ore, and any quantity of timber to make charcoal to convert it into iron. All it requires is the adoption of this policy in order to establish at an early day industries for the manufacture of iron in the North-West as well as in the other portions of the country. Across the Rocky mountains, need I tell you that in British Columbia you have one of the most magnificient deposits of iron ore—on Texada Island (30 miles long and 5 miles wide)—that is to be found in any place in the world, rich in the highest degree in iron; and that you have the Nanaimo coal fields to furnish fuel to put blast furnaces in operation at an early day, lying within thirty miles of Texada Island. Our present consumption is equivalent to 250,000 tons of pig iron, leaving steel rails out of the question altogether.

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*The analyses given in the speech are evidently of ores dried at 212°—ED.

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"There is at present provided by law a bounty of $1 50 a ton until the 30th of June, 1889, on every ton of pig iron manufactured in the country; and afterwards that bounty is a $1 00 a ton, until it ends in June, 1892. We of course leave that as it is; and in the meantime, instead of adopting the American tariff of $6 00 a ton upon pig iron, we propose to adopt two-thirds of that tariff by raising the duty from $2 00 a ton, as it is at present, to $4 00 in addition to the bounty. And then we have applied as a general principle—modified in certain cases according as we felt it desirable in the interest of the country, a little more or a little less—that two-thirds rate to all the branches of the iron industry throughout the country. We do not propose to increase the tariff on sheet iron, hoop iron, or the lower kinds of round iron, which are left at the old rate at present, because these I do not expect at an early day to be manufactured in the country. The duty on steel worth 4 cents per lb. and under, is placed at 30 per cent., or on an equal footing with the iron duty. On steel worth over 4 cents per lb., we leave the revenue duty of 12½ per cent., because we do not expect that high class of steel at an early day to be manufactured in the country; so that miners and others using a high class of steel will not be affected adversely by the change. On wire rods, wire rope and wire fencing the duty is not proposed to be increased. The duty on boiler plate and locomotive tubes remains, for obvious reasons, unchanged, as we wish to do all we can to develop the manufacture of engines in our own country, and to furnish all the aid we can to railways. The highest *ad valorem* rate, therefore, on them, under the proposed tariff, would be about 35 per cent. The unenumerated articles, embracing hardware stores, edge tools, cutlery, &c., will come in at 30 per cent. duty."

To add to the value of the data given in the closing paragraphs above, the following are presented as some of the provisions of the tariff resolutions as finally adopted. No attempt has been made to give more than an idea of the new duties upon some of the articles in which our readers will be most likely to be interested:

(The numbers refer to the paragraphs in the customs schedule.)

39. Wrought scrap iron and scrap steel, being waste or refuse wrought iron or steel that has been in actual use, and is fit only to be re-manufactured, two dollars per ton.

40. Ferro manganese, ferro silicon, spiegel, steel bloom ends, and crop ends of steel rails, for the manufacture of steel, two dollars per ton.

41. Iron in pigs, iron kentledge and cast scrap iron, four dollars per ton.

42. Iron in slabs, blooms, loops, puddled bars, or other forms less finished than iron in bars, and more advanced than pig iron, except castings, nine dollars per ton.

43. Bar iron, rolled or hammered, comprising flats, rounds and squares, and bars and shapes of rolled iron, not elsewhere specified, thirteen dollars per ton.

44. Iron and steel wire, galvanized or not, fifteen gauge and coarser, not elsewhere specified, twenty-five per cent. *ad valorem.*

46. Boiler or other plate iron, sheared or unsheared, skelp iron, sheared or rolled in grooves, and sheet iron, common or black, not thinner than number twenty gauge, not elsewhere specified, including nail plate of iron or steel, sixteen gauge and thicker, thirteen dollars per ton.

47. Sheet iron, common or black, smoothed or polished, and coated or galvanized, thinner than number twenty gauge, Canada plates, and plate of iron or steel, not less than thirty inches wide, and not less than one-fourth of an inch in thickness, twelve and a-half per cent. *ad valorem.*

60. Provided further, that all metal produced from iron or its ores, which is cast and malleable, of whatever description or form, without regard to the percentage of carbon contained therein, whether produced by cementation, or converted, cast or made from iron or its ores by the crucible, Bessemer, pneumatic, Thomas Gilchrist, basic, Siemens-Martin or open hearth process, or by the equivalent of either, or by the combination of two or more of the processes or their equivalents, or by any fusion or other process which produces from iron or its ores a metal either granulous or fibrous in structure, which is cast and malleable, except what is known as malleable iron castings, shall be classed and denominated as steel.

61. Provided further, that all articles rated as iron or manufacture of iron, shall be chargeable with the same rate of duty if made of steel, or of steel and iron combined, unless otherwise specially provided for.

62. Malleable iron castings, and steel castings not elsewhere specified, twenty-five dollars per ton, provided the duty shall not be less than thirty per cent. *ad valorem.*

70. Boiler tubes of wrought iron or steel, fifteen per cent. *ad valorem.*

71. Tubes not welded, nor more than one and one-half inch in diameter, of rolled steel, fifteen per cent. *ad valorem.*

77. Wire rope of iron or steel, not otherwise provided for, twenty-five per cent. *ad valorem.*

82. Nails and spikes, wrought and pressed, galvanized or not, horse shoe nails, hob nails and wire nails, and all other wrought iron or steel nails, not elsewhere specified, and horse, mule or ox shoes, one and a-half cent per lb., but not less than thirty-five per cent. *ad valorem.*

86. Cut nails and spikes of iron or steel, one cent per pound.

87. Swedish rolled iron nail rods, under a half inch in diameter, for manufacture of horse shoe nails, twenty per cent. *ad valorem.*

89. Manufactures, articles or wares not specially enumerated or provided for, composed wholly or in part of iron or steel, and whether partly or wholly manufactured, thirty per cent. *ad valorem.*

An examination of the tariff schedule indicates that our Canadian friends have profited by the ambiguity of some portions of our customs regulations, and have endeavored to make the law less susceptible than our tariff, to misconstructions by revenue officials.

Among the articles which are duty-free are anthracite coal, fire-brick, and special sizes or shapes of wrought or cast iron or steel, required by certain industries which the Dominion Government is desirous of encouraging. Steel rails, weighing not less than 25 pounds per yard; wire of iron or steel, galvanized or tinned, No. 16 guage or smaller; wire rigging for ships; and wood for fuel, when imported into Manitoba and the north-west Territories, are also free of duty.

The Journal.

The usual interval between the last issue of the JOURNAL and the present number demands an explanation on the part of the Editor. It is well known to the members of the United States Association of Charcoal Iron-Workers that the policy of the management has been to avoid any indebtedness, and at the last annual meeting, efforts were made to place the organization upon a sound financial basis. This in part succeeded, but an insufficient amount of money was secured to permit of making the expenditures which were thought advisable, and it was determined not to appropriate money to the publication of the JOURNAL faster than it was received; but as an experiment, it was decided that the interval of publication should be temporarily lengthened. It was not. however, the intention or desire to make this interval as great as has been the case, but the enforced absence of the Editor, upon whom the preparation of the JOURNAL individually depends, prevented an earlier issue. It is his wish to compensate if possible for the delay by additional interest in the future.

One gratifying feature of the long interval has been the numerous inquiries which have come from our readers, showing that the JOURNAL is appreciated and considered of value. For all the kind expressions of interest in the JOURNAL we are truly grateful, and it is a matter of satisfaction to know that our publication has been missed by those accustomed to receive it.

Obituary.

We regret to be called upon to chronicle the death of Mr. George D. Colby. superintendent of the Gere Iron and Mining Company of Port Leyden, New York.

Mr. Colby was one of our members who has contributed some interesting data to the JOURNAL; his whole life having been spent in the manufacture of charcoal iron. As a boy he started at the East Canaan Furnaces, Connecticut, where he remained for some years and then took charge of the Kathadin Furnace in Maine, during which time he, in connection with Mr. Davis, perfected an ore roaster. Since 1884 he has been in charge of the Gere Iron and Mining Company of Port Leyden, New York, and during the year 1886 he operated the charcoal retort plant under lease, having, it is reported, done a profitable business in the disposal of his charcoal, acetate, etc. Mr. Colby was in his thirty-fifth year; he met his death by drowning in the St. Lawrence river while bathing in company with his family and friends, he leaves a widow, a son and daughter to whom we are sure every member of the United States Association of Charcoal Iron Workers extends his kind sympathies.

The Behavior of Pig-Iron when Heated in Wood Charcoal.

Some very interesting experiments have recently been made by Herr A. Ledebur with pigs containing very little silicon, and varying proportions of phosphorus and manganese. Nine test pieces of various kinds were packed separately, amidst small fragments of charcoal, in a pot, such as is used for making malleable castings. They were then heated to about 1000 degrees C. for one hundred and eight hours. On examining the samples it was found that in all malleable irons the percentage of carbon had increased; thus in

Fibrous wrought iron from, ...	**0.10 to 0.58**	**per cent.**
Thomas steel from, ...	**0.11 to 0.26**	**"**
Cast steel from, ...	**0.40 to 0.65**	**"**

Similarly in a manganiferous (2.75 per cent. Mn.) cast iron for the Thomas process, the carbon had increased from 2.63 to 3.27 per cent., whilst in a refined Lowmoor iron, with but a trace of manganese, it was constant at 3.5 per cent; in all the other specimens there was actually a diminuation in the amount of carbon. Thus, although confirmatory of previous experiments, no further light is thrown on the cause of the decrease noted with so many samples of cast iron. The silicon and phosphorous percentages alike remain unchanged. With the alteration in composition was a corresponding change in the appearance and in the physical properties, all specimens with less than 1 per cent. of manganese having become granular, soft, and comparatively tough, whilst the manganese Thomas cast iron above alluded to remained unaltered in fracture and in brittleness.

Speculation in Iron Industries.

Americans are often credited with an imitative nature, and critics assert that we copy blindly from one another. In this connection we have referred to the fact that in the details of construction of our iron works there has been a great deal of what would probably be called copying, often without regard to the peculiar surroundings or adaptability to location, but it is not in construction only that we copy for we are as apt to imitate in practice as in plan, or to be infected with any bearish or bullish sentiment which prevails.

Business has its ups and downs, its seasons of elevation and depression, its booms and crises following each other in such cycles, that efforts have been made to base prognostications of the future upon the history of the past. The apparent verifications of these returning cycles has given to one publication quite a wide circulation, and the tendency seems to be to start out with expectations that the prophecies are to be fulfilled and with a determination to be disappointed if such is not the case. We know of no better way to cause a depression in business than to have those engaged in a special industry expecting bad times, and concerted enthusiasm goes far towards instilling confidence.

There are those in the iron business who, while not in the majority, are yet in sufficient numbers to have at times material influence upon the trade, who are continually hunting for something upon which to hang their chronic expectation and prophecy evil. If they fail to get the price they ask of the manufacturer by twenty-five cents, they claim that there is no business, or put the responsibility upon the cost of fuel or labor; and if, through want of knowledge, they are unable to turn out their product as cheaply as a neighboring plant, they constantly affirm that those who undersell them are losing money. If a failure occurs where an iron works has mortgaged its property for double its value they see in this collapse "the beginning of the end."

These are not the men to whom the iron industry is indebted for its success, on the contrary, they are a constant break upon progress. They call themselves conservative but they are fully as radical as their brothers who take the other horn of the dilemma and are over-sanguine. Less injury has, however, resulted to the iron trade from the enthusiast than from the chronic bear, up to the present times.

But the enthusiast has lately come to the front in a way which threatens before long to seriously disturb the financial condition of many whose investments were guided neither by conservatism nor by investigations. This enthusiasm has taken different forms in various parts of the country, but where it will influence the iron trade particularly is in the effort to float numerous mining enterprises in the north-west and an attempt to combine blast-furnace construction and land speculation in the south. We have unbounded faith in the iron ore resources of the north-west; for looking back over the history of the Marquette and Menominee districts we recognize what an important factor these iron ore mines have been in the national development. Just at a time when the growing demands for rich iron ores seemed to threaten a shortage from the older districts, the opening of the Gogebic Range, as described in the JOURNAL, pages 155 to 164, and of the Vermilion Range in Minnesota relieved the market of any strain, and assured a bountiful supply of high grade ores for years to come. A personal investigation of these iron ore deposits cannot fail to impress one with their enormous value, but it will also at the same time convince him that the system of over-capitalization employed cannot but result injuriously in the end to investors. The policy of placing a capital of $500,000 on each 40 acres of land through which the ore vein apparently strikes, and guaranteeing to produce from each 40 acres 5,000 tons of ore per annum or pay the royalty of fifty cents per ton on that amount, cannot but be an injurious one, and the spectacle of companies having a million dollars nominal capital, with two or three shallow openings in the ore, being months in arrears of their employees, or having a mining equipment held by the manufacturers for payment is far from reassuring. As a result several consolidation schemes are now under way, by which the share capital is absorbed at but a fraction of its par value, but whether or no they are successful will have little ultimate affect upon the original investors who have been encouraged to gamble against impossibilities.

There is a very limited section of the territory embraced in the apparent strike of the ore-bearing rock in either the Vermilion or Gogebic districts which will fail to yield a good return for the capital legitimately required for actual exploitation, and on the other hand it may be said that in only a few locations is there any encouragement to believe that legal interest can be paid upon the large capitalization and permit of excessive royalties; it is doubtful too if these few localities can ever pay proper interest on the capitalization for a series of years; for the open-pit bonanza must eventually give place to underground workings, with a consequent expense of timbering, etc., and the temporary slopes which have been sunk on the foot wall in soft ore will prove too costly to be maintained and will be supplanted by a more permanent arrangement.

Scarcely less dangerous is the fever for the construction of blast-furnaces, which has run riot through some of the southern States, encouraging the erection of plants in advance of the local requirements, in advance of the opening of coal mines from which to obtain fuel, or of judicious investigation of the adaptability of such fuel, and, in some cases, without taking into consideration the necessity of an abundant supply of ore. We believe in the southern development, we recognize that in Alabama and Tennessee, particularly in the former, coal and ore lie close together, and we see industries growing up which will be large consumers of pig-iron; we note the area covered by the ore and coal fields, and we note too the more rapid increase of blast furnace construction. We believe this increase is in advance of the market, which can be legitimately claimed for the various districts, that it is in advance of the coal mining and coke producing development, and that in some cases is in advance of judicious exploitations for ore. Taking one of these, the most prominent for example, we find that it is claimed that there is now in the Birmingham district

	10	blast-furnaces	in operation with a daily capacity of, . . .	855 tons.
	21	"	under construction with a daily capacity of	1,650 "
	3	"	under contract with a daily capacity of, .	375 "
Total	34	blast furnaces	under contract with a daily capacity of . .	2,880 "

If we assume that these furnaces run three hundred days per year we have a yearly output of 864,000 tons, and to make still further allowance we will assume the total at 800,000 tons per annum. Now to produce this amount of iron will require the mining of more ore from Alabama than has ever been produced in one year from the Marquette Region of Lake Superior, and over 2,000,000 tons of coal must be coked annually to supply these blast-furnaces with fuel.

The extent of the mining which will be necessary to produce the quantity of ore above named will be appreciated by the statement that without allowing for any deterioration as the ore passes under cover, or estimating for any ore left at pillars, each year would require the removal of the ore from a seam averaging ten feet in thickness to a depth of forty feet for ten miles along the strike of the vein, and similar calculations might be made as to coal mining.

No one questions the abundance of coal or ore in Alabama and Tennessee, but the abnormal development which has lately taken place in that region naturally leads to the conclusion that the immense drain upon the resources which will be necessary to bring this largely augmented producing capacity into activity, will soon either cause an apparent scarcity of ore or else advance prices to the figures which will rob the South of its glory in producing cheap iron.

We are far from desiring to convey the impression that we fail to recognize the mineral wealth or natural advantages of either the North-west or the South. Any real, practical development of either section must advance the nation's wealth, and we should all rejoice in the progressive spirit which seeks to take advantage of the mineral which nature has bestowed. But while we should unite in commending the judicious employment of local resources, we should with caution note the results which sooner or later will follow wild speculation. That some of the enterprises which have lately been placed before the public will result disastrously any candid observer can demonstrate, and that others will be financially successful is equally certain; but it will take the confidence inspired by more than one good blast-furnace enterprise to undo the evil wrought by one unsuccessful scheme to open a mine upon paper, having for its sole asset the privilege of paying a fixed royalty for a number of tons whether the ore is mined or not; or for any blast-furnace plant erected where neither ore or fuel are sufficient but where broad avenues and corner lots are special inducements.

There are plenty of chances for good investments in ore mining or blast-furnace construction in the United States, but we fear that when settlement time comes for some of newer enterprises confidence will be badly shaken, and those who "leaped before they looked" will be the sufferers directly, while indirectly many legitimate enterprises will temporarily feel the depressing influence arising from broken confidence. It is well, therefore, to look at this matter in candor and be prepared to discount the results when they become apparent. The struggle for trade may be sharp when all the projected plants are in operation, but it will be short, and those who have used wisdom in selecting locations, or applied judicious methods in securing supplies of material, will be able to withstand the competition. We do not fear a panic, but it is natural to expect that capital will temporarily lose faith in investments in iron mining or manufacture.

Fortunately the charcoal iron industry has entered into the speculative feature on but a limited scale; but it is not free from enterprises which appear to be removed from what is esteemed as legitimate development. We can only hope that all may be successful, but in some cases at least we fear the hope will be of the deferred kind which "maketh the heart sick."

Blast Furnace Records.

We have frequently directed the attention of the readers of the JOURNAL to the excellent results obtained at some of the Michigan Charcoal blast furnaces, until it seems like an old story to repeat their achievements in iron production. We lately had an opportunity to inspect the weekly reports of several of these furnaces. and hope in the furure to be able to give to our readers complete data concerning their operation. The following, however, has been published as the results obtained at the charcoal furnace of the Antrim Iron Company at Mancelona, Michigan (lower peninsula).

The stack is 48 feet high, and the diameter of the bosh is 8 feet 6 inches. The following is a statement of the working of the furnace for the year ending June 1, 1887:

Days run,	340
Bushels of charcoal used,	1,312,680
Tons of ore used,	27,064
Tons of limestone used,	1,122
Furnace charges run,	43,171
Blank charges run,	585
Tons of pig iron made,	16,152
Bushels of charcoal per ton of iron.	81½
Pounds of lime stone per ton of iron,	156
Pounds of ore smelted per ton of iron,	3,754
Pounds of ore smelted per bushel of coal,	46⅕

Average number of gross tons of pig iron made per day, .	47½
Per cent. of yield of ore, ...	60
Per cent. of hematite ore used, ...	80
Per cent. of specular ore used, ...	20
Average blast pressure, pounds, ...	3½
Average blast temperature, ...	850°
Average steam pressure, pounds, ...	75
Average revolution per minute of blowing engine, . . .	47

The oven is on the Player plan, having 27 U pipes, each 12 feet high, furnishing 950° temperature of blast. The engine used is a Weimer; 16 x 30 steam cylinder, and 30 x 48 blast cylinder. The ores used were Lake Superior Iron Company's specular, Lake Superior old mine hematite, Cleveland Iron Company's fine Scotch, Winthrop Hematite Company's mitchel. Petoskey limestone was used and the wood for coaling was of excellent quality—principly maple, beech and elm. The largest day's run by this furnace was 56 tons. The furnace is situated on a small inland lake and on the line of the Grand Rapids and Indiana Railroad. The ores are received direct from the mines by rail and are dumped into the stock-house from an elevated track. The freight of the ore from the mines laid down in the stock-house is $1.60 per ton. Freight to Chicago on the iron $2.25 per ton. The wood costs from $1.25 to $1.35 per cord. Wages paid, $1.25 to $2 per day.

Since the company took possion of the property, March 15, 1886, a 75 barrel lime kiln has been built and 33 charcoal kilns erected—making altogether 43 kilns (of 50 cords capacity) for the manufacture of coal.

A correspondent of the *Scientific American* says: "In a variety of bituminous coal that comes from Tennessee, there are to be seen along the cleavage planes films of true charcoal, in varying quantity, but commonly thin. This coal has been coming to us for several years, and all the while I have noticed in it the presence of the charcoal. I have scarcely ever put coal into the fire without making the observation; and there is, perhaps, not a lump, of size at all considerable, that does not contain these films. On close examination I have frequently found that the surface of the films on the broken lumps contains a delicate tracery, closely resembling vegetable impressions. The tracery is not so well marked as a fossil imprint, but not so indistinct as to escape notice."

The Status of Charcoal Pig-Iron.

The gradual and nearly constant decrease in the number of blast furnaces using charcoal as fuel has given rise to a prevailing opinion that this branch of the iron industry exhibits a decadence greater than is really the case; for by the rapid denudation of forest areas and the active exploitation of coal mines, the supplanting of vegetable by mineral fuel in many blast-furnaces is natural, and the employment of the cheapest combustible with which to accomplish any desired result is to be expected.

The growth of the charcoal iron industry cannot be expected to keep pace with the employment of mineral fuels, for, in a majority of instances, present practice does not permit of producing a ton of pig-iron as cheaply with charcoal as with coal or coke.

First. Because the economical location of the furnace plants dependent upon vegetable fuel is confined within narrower limits than where mineral fuel is employed.

Second. Because a too rapid expansion of charcoal iron production would denude the wooded areas of the country at such a rate as to make these furnaces destroyers rather than, as they should be, conservators of forest growth; and

Third. Because too many of the iron works dependent upon charcoal as fuel are slow in adopting the modern improvements and appliances which have done so much to bring to its present proportions the iron-producing industry of the United States.

To indicate the growth of the pig-iron industry, let us examine the production of pig-iron in the United States in 1886, classified according to the character of the fuel used, as compared with the output from 1880 to 1885, in net tons:

FUEL USED.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Bituminous, ...	1,950,205	2,268,264	2,438,078	2,689,650	2,544,742	2,675,635	3,806,174
Anthracite, ...	1,807,651	1,734,462	2,042,138	1,885,596	1,586,453	1,454,390	2,099,597
Charcoal, ...	537,558	638,838	697,906	571,726	458,418	399,844	459,557
Total, ...	4,295,414	4,641,564	5,178,122	5,146,972	4,589,613	4,529,869	6,365,328

A more satisfactory exhibit of the relative advance and decline is presented in the following table of percentages of increase or decrease in pig-iron production from 1879 to 1886, or during the existence of the United States Association of Charcoal Iron-Workers:

PERCENTAGE OF INCREASE OR DECREASE.

FUEL.	1879 over 1878.	1880 over 1879.	1881 over 1880.	1882 over 1881.	1883 over or less than 1882.	1884 less than 1883.	1885 over or less than 1884.	1886 over 1885.	1886 over 1878.
Anthracite coal,	16.5	41.9	*4	17.7	*7.66	*15.8	*8.8	44.4	90.2
Bituminous coal,	20.5	35.52	16.3	7.5	10.3	*5.3	5.1	42.2	219.6
Charcoal,	**22.3**	**49.79**	**18.8**	**9.25**	***18**	***19.8**	***12.8**	**14.5**	**56.6**
Total,	19.1	39.8	8	11.5	6.6	*10.8	*1.3	40.5	147.0

This statement covers but a limited time, but to show the number of tons produced with the various fuels, and the proportions which each bears to the total for a greater period, we offer the annexed statement, exhibiting the production of pig-iron according to fuel used from 1854 to 1886, both inclusive:

YEARS	NET TONS OF 2,000 POUNDS.				PERCENTAGES OF TOTAL MAKE.		
	Anthracite.	Charcoal.	Bituminous.	Total.	Anthracite.	Charcoal.	Bituminous.
1854,	339,435	342,298	54,485	736,218	46.10	**46.49**	7.41
1855,	381,866	339,922	62,390	784,178	48.70	43.35	7.95
1856,	443,113	370,470	69,554	883,137	50.17	41.95	7.88
1857,	390,385	330,321	77,451	798,157	48.91	41.39	9.70
1858,	361,430	285,313	58,351	705,094	51.26	40.46	8.28
1859,	471,745	284,041	84,841	840,627	56.12	33.79	10.09
1860,	519,211	278,331	122,228	919,770	56.45	30.24	13.27
1861,	409,229	195,278	127,037	731,544	55.94	26.69	17.37
1862,	470,315	186,660	130,687	787,662	59.71	23.69	16.60
1863,	577,638	212,005	157,961	947,604	**60.96**	22.37	16.67
1864,	684,018	241,853	210,125	1,135,996	60.21	21.29	18.50
1865,	479,558	262,342	189,682	931,582	51.46	28.16	20.38
1866,	749,367	332,580	268,396	1,350,343	55.49	24.63	19.88
1867,	798,638	344,341	318,647	1,461,626	54.64	23.56	21.80
1868,	893,000	370,000	340,000	1,603,000	55.71	23.18	21.21
1869,	971,150	392,150	553,341	1,916,641	50.67	20.46	28.87
1870,	930,000	365,000	570,000	1,860,000	50.00	19.62	30.38
1871,	956,608	385,000	570,000	1,911,608	50.04	20.14	29.82
1872,	1,369,812	500,587	984,159	2,854,558	47.98	17.54	34.48
1873,	1,312,754	577,620	977,904	2,868,278	45.77	20.14	34.09
1874,	1,202,144	576,557	910,712	2,689,413	44.69	21.44	33.87
1875,	908,046	410,990	947,545	2,266,581	38.87	17.87	44.26
1876,	794,578	308,649	990,009	2,093,236	37.96	14.75	47.29
1877,	934,797	317,843	1,061,945	2,314,585	40.39	13.73	45.88
1878,	1,092,870	293,399	1,191,092	2,577,361	42.40	11.38	46.22
1879,	1,273,024	358,873	1,438,978	3,070,875	41.45	11.68	46.87
1880,	1,807,651	537,558	1,950,205	4,295,414	42.09	12.51	45.40
1881,	1,734,462	638,838	2,268,264	4,641,564	37.37	13.76	48.87
1882,	2,042,138	**697,906**	2,438,078	5,178,122	39.44	13.48	47.08
1883,	1,885,596	571,726	2,689,650	5,146,972	36.64	11.11	52.25
1884,	1,586,453	458,418	2,544,742	4,589,613	34.57	9.99	55.44
1885,	1,454,390	399,844	2,675,635	4,529,869	32.11	8.83	59.06
1886,	**2,099,597**	459,557	**3,806,174**	**6,365,328**	32.99	7.22	**59.79**

* indicates decrease. In all the tables full-faced figures indicate the maxima.

These figures, as well as those which follow, have been taken from the statistical reports of the American Iron and Steel Association, which Mr. James M. Swank has, by his conscientious efforts to secure absolutely correct data, made an authority unexcelled by any other presentation of iron production in the world. The figures show that although the decrease in the percentage of pig-iron made with charcoal has been practically continuous, we can scarcely claim a decline in the industry, for, with the exception of seven years, viz: 1872, 1873, 1874, 1880, 1881, 1882 and 1883, (all years of unusual activity,) the quantity of pig metal produced in the charcoal blast furnaces in 1886 was not exceeded, and the output of the charcoal furnaces by decades is as follows:

	Total net tons.	Yearly average net tons.
Years 1857 to 1866, (inclusive,) . . .	2.608,724	260.872
Years 1867 to 1876, (inclusive,) . . .	4.230,894	423,089
Years 1877 to 1886, (inclusive,) . . .	4,733,962	473,396

These figures demonstrate a material advance in the average amount of charcoal pig-iron produced, notwithstanding the fact that relatively the importance of this branch of industry has declined.

That the year 1887 promises as good results in all classes of pig-iron production as its predecessor will be evident from the following data, published in the Bulletin of the American Iron and Steel Association:

"Our production of pig-iron in the first half of 1887 was divided among the fuels used as follows, in net tons: Bituminous, 1,953,032 tons; mixed anthracite and coke, 944,269 tons; anthracite alone, 257,174 tons: charcoal, 263,428 tons; total, 3,417,903 tons. These details are given below in comparison with similar data for the last half of 1886:

FUEL USED—Net tons.	Last half of 1886.	First half of 1887.
Bituminous, ...	2,060,613	1,953,032
Mixed anthracite and coke, ...	846,650	944,269
Anthracite alone, ...	241,190	257,174
Charcoal, ...	262,666	263,428
Total, ...	3,411,119	3,417,903

To indicate more clearly the prospective condition of the trade, the following figures representing the comparison of charcoal pig-iron production in the last three half years are given:

STATES.	BLAST FURNACES IN OPERATION.		PRODUCTION. TONS OF 2,000 POUNDS. (Includes spiegeleisen.)		
	January 1, 1887.	July 1, 1887.	First half of 1886.	Second half of 1886.	First half of 1887.
Maine,	1	1	2,420	2,640	2,850
Massachusetts,	1	2	3,886	4,288	5,875
Connecticut,	5	4	10,245	9,145	10,684
New York,	4	3	6,132	8,218	14,201
Pennsylvania,	6	5	7,407	9,310	4,108
Maryland,	1	3	4,068	8,804	6,389
Virginia,	4	7	1,096	4,973	2,835
North Carolina,	1	1	1,000	1,200	1,400
Georgia,	......	......	459		
Alabama,	8	10	37,789	44,331	48,096
Texas,	......	......	250	3,000	1,929
West Virginia.					
Kentucky,	2	1	1,332	5,081	697
Tennessee,	5	4	11,361	16,011	17,813
Ohio,	6	9	5,755	10,406	5,776
Michigan,	13	16	89,105	101,629	95,466
Wisconsin,	3	3	7,784	20,708	21,393
Missouri,	2	3	5,052	15,125	22,330
Minnesota.					
Oregon.					
California,	......	......	1,750		
Washington Territory,	1	......	......	2,842	1,586
Total,	63	72	196,891	262,666	263,428

As most of the wood for charcoal iron works is cut during the winter months, probably the fairest comparison of the present and past condition of the charcoal furnaces is between the figures for the first half of 1886 and the first half of 1887, rather than in the two consecutive periods from July 1, 1886, to July 1, 1887. But the market facilities offered by certain commercial centers have to a considerable extent obliterated State lines and brought the product of blast furnaces more into recognition by districts, and we present as an index of the status of charcoal iron manufacture a comparison based upon the division which has heretofore been adopted in the JOURNAL.

In arranging the charcoal blast furnaces into divisions or districts, we have endeavored to group them in such order as to approximately represent commercial sections, but at the same time we must remember that certain furnaces in a district are producers of special grades of iron, which command a market not restricted by local considerations. The groupings selected are—

Northern district, including the furnaces of Maine and northern New York.

Salisbury district, embracing the furnaces in Connecticut, Massachusetts, and south-eastern New York.

Pennsylvania district, furnaces in Pennsylvania.

Baltimore district, comprising the furnaces in Maryland, Virginia, and West Virginia.

Southern district, embracing the furnaces of Alabama, Georgia, Tennessee, North Carolina, and part of Kentucky.

Hanging Rock district, of Ohio and Kentucky.

Lake Superior district, embracing the furnaces using Lake Superior ores, including all in Michigan and Minnesota, and a part of those in Wisconsin, and those of north-western Ohio. The furnaces omitted from Wisconsin quota are those using local ores.

Western district, all charcoal furnaces west of the Mississippi river. (This includes Texas.)

According to this division, the annexed statement exhibits the amount of pig-iron made in each of the years 1880, 1881, 1882, 1883, 1884, 1885 and 1886, and gives a general idea of their relative importance:

	NET TONS.						
	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Northern district,	14,651	**16,924**	16,583	10,735	6,498	3,544	5,060
Salisbury district,	51,016	**61,582**	54,120	50,081	36,068	29,947	41,894
Pennsylvania dis.,	43,374	**51,908**	49,975	38,315	23,155	12,148	16,727
Baltimore district,	50,338	47,864	**54,410**	40,686	29,952	23,080	13,941
Southern district,	66,179	82,060	116,044	109,229	88,304	**116,333**	112,171
Hanging Rock dis.,	**81,538**	73,676	66,534	48,615	32,762	22,725	22,524
Lake Superior dis.,	199,573	241,284	**275,118**	217,154	196,646	155,823	219,221
Western district,	23,269	54,955	**63,442**	51,137	43,035	29,317	28,019

The maximum annual product of each district is given in full-faced figures.

This table indicates that the districts in 1880 and 1886 ranked as follows:

1880.	1886.
Lake Superior district.	**Lake Superior district.**
Hanging Rock “	**Southern** “
Southern “	**Salisbury** “
Salisbury “	**Western** “
Baltimore “	**Hanging Rock** “
Pennsylvania “	**Pennsylvania** “
Western “	**Baltimore** “
Northern “	**Northern** “

We note that the Lake Superior district has maintained its preëminence, although the product in 1886 was considerably less than in 1881 and 1882; and it seems probable that the make of 1887 will approximate that of 1882, which was the maximum attained by this region.

The Southern district which ranked third in 1880, advanced to second place in 1881, which position it has maintained to date. In 1882 and 1885 the Southern district made more charcoal pig-iron than in 1886; however the figures for the first half of 1887 indicate a greater output for this year than the maximum of 1885. The new blast-furnaces which are being added to the southern charcoal industry will favor a still larger output in 1888.

The Salisbury district has practically ranked fourth from 1880 until 1885, rising in the latter year to third place, which it maintained in 1886; although the amount of pig-iron produced last year was less than in any year from 1880 to 1884.

The production of the Western district in 1886 was about 20 per cent. greater than in 1880, but owing to the decline in the other districts it rose from seventh to fourth place, although the maximum output in 1882 was more than double that of 1886. The probabilities are that the Western district will show a material increase in 1887.

The Hanging Rock district indicates a notably continuous decadence, it having dropped from second to fifth place in seven years, and the product in 1886 being less than 30 per cent. of what it was in 1880.

Pennsylvania holds the same relative position (sixth), although its output in 1886 was but about one third that of 1881. 1887 does not indicate an advance.

The production in the Baltimore district reached its maximum in 1882, when, as in 1880, it was fifth in order of production, but in 1886 it fell to seventh place, and its output was but one-fourth of what it was in its maximum year.

The make of the Northern district is so small that the activity of a single furnace materially influences it, but it, like others, has declined in production.

We thus see that the importance of the charcoal pig-iron industry has been maintained chiefly by the blast-furnaces in the Lake Superior, Southern, and Salisbury districts, and a study of the influences which have led to the changes in the relative positions of the different districts will be an interesting topic for each of our readers to undertake.

The following statement has been prepared to show the proportions of the charcoal pig-iron made by each district in 1886, and also in the seven years, 1880 to 1886, inclusive:

	1886.		1880-1886.	
	Net tons made.	Per cent. of total.	Net tons made.	Per cent. of total.
Northern district,	5,060	1.1	73,995	1.9
Salisbury district,	41,894	9.1	324,706	8.8
Pennsylvania district,	16,727	3.6	235,602	6.3
Baltimore district,	13,941	3.0	260,271	7.0
Southern district,	112,171	24.4	690,320	18.5
Hanging Rock district,	22,524	5.0	348,374	9.3
Lake Superior district,	219,221	47.7	1,504,819	40.3
Western district,	28,019	6.1	293,174	7.9
Total,	459,557	100.0	3,731,261	100.0

Again referring to the output during the past eighteen months we find that the pig-iron production, according to fuel used, was:

FUEL USED.	BLAST FURNACES IN BLAST.			PRODUCTION. TONS OF 2,000 POUNDS. (Includes spiegeleisen.)		
	July 1, 1886.	Jan. 1, 1887.	July 1, 1887.	First half of 1886.	Second half of 1886.	First half of 1887.
Anthracite,	117	125	137	1,011,757	1,087,840	1,201,443
Charcoal,	61	63	72	196,891	262,666	263,428
Bituminous,	136	143	98	1,745,561	2,060,613	1,953,032
Total,	314	331	307	2,954,209	3,411,119	3,417,903

The decrease in the amount of charcoal iron produced has occurred chiefly in the older settled sections of the country, but, as shown above, the augmented outputs of the newer districts have more than equalized this tendency towards restricted production. This will be evident by comparing the following tables with others of similar character which have appeared previously in the JOURNAL. In the table on page 218 the States are placed in their order as producers of charcoal pig-iron, based upon the output of 1886, but the record of 1882 is also noted, when, under conditions unusually favorable, many blast-furnaces were operated, which since that time have been inactive, and some of them have been abandoned. The table also shows the number of charcoal blast-furnaces operating at the close of the last three years.

The *American Manufactures* reports the number of furnaces in blast, and their capacities on the first of each month since January 1, 1886, is as follows:

DATE.	CHARCOAL.		ANTHRACITE.		BITUMINOUS.	
	Number.	Weekly Capacity.	Number.	Weekly Capacity.	Number.	Weekly Capacity.
1886.						
January 1,	57	7,804	104	29,811	112	59,436
February 1,	52	7,403	107	30,100	109	56,277
March 1,	46	6,515	104	30,115	105	55,079
April 1,	44	6,766	117	33,280	118	66,756
May 1,	47	8,462	122	37,767	128	68,106
June 1,	54	9,884	123	35,136	131	75,750
July 1,	59	10,420	119	33,225	132	78,005
August 1,	63	10,980	119	33,602	131	77,460
September 1,	66	11,105	121	34,091	132	76,270
October 1,	59	11,271	118	33,476	135	77,127
November 1,	62	10,565	112	32,761	138	79,405
December 1,	67	11,818	115	32,634	141	78,832
1887.						
January 1,	66	11,895	126	35,633	140	80,132
February 1,	68	12,235	137	38,049	148	85,921
March 1,	61	11,572	142	39,767	146	83,834
April 1,	59	11,337	143	39,477	151	86,709
May 1,	54	10,819	143	40,873	149	86,822
June 1,	62	11,809	145	41,288	104	54,767
July 1,	77	13,969	136	37,662	101	57,355
August 1,	80	14,396	127	35,278	120	70,855
September 1,	79	13,900	130	36,872	143	87,953
October 1,	73	15,171	122	36,044	151	93,423

Production of Charcoal Pig-Iron in 1885 *and* 1886, *by States.*

STATES.	CONDITION OF BLAST FURNACES.					PRODUCTION, NET TONS, (2,000 LBS.)	
			JANUARY 1, 1887.				
	In blast January 1, 1885.	In blast January 1, 1886.	In blast.	Out of blast.	Total.	1882, maximum year.	1886.
1. Michigan,*	11	10	13	12	25	210,195	190,734
2. Alabama,	8	9	8	2	10	55,541	82,110
3. Wisconsin,	3	1	3	8	11	55,369	28,487
4. Tennessee,	4	4	5	4	9	37,611	27,402
5. Missouri,	0	1	2	2	4	54,327	20,177
6. Connecticut,*	2	5	5	4	9	24,342	19,390
7. Pennsylvania,	5	8	6	16	22	49,975	16,727
8. Ohio,	10	4	6	11	17	58,654	16,161
9. New York,	5	3	4	5	9	30,716	14,380
10. Massachusetts,*	0	2	1	3	4	10,335	8,124
11. Maryland,	4	0	1	12	13	28,277	7,872
12. Kentucky,	2	1	2	1	3	17,165	6,363
13. Virginia,	7	7	4	19	23	26,133	6,069
14. Maine,*	0	1	1	0	1	4,100	5,060
15. Texas,*	1	1	0	2	2	1,321	3,250
16. Washington Ter.,*	1	0	1	0	1	. . . . .	2,842
17. North Carolina,*	1	1	1	1	2	1,150	2,200
18. California,*	. . .	0	0	1	1	987	1,750
19. Georgia,	1	2	0	2	2	15,565	459
20. Minnesota,*	0	0	0	1	1	8,126	
21. Oregon,*	1	0	0	1	1	6,750	
22. Vermont,	. . .	0	0	0	0	1,210	
23. Utah,	. . .	0	0	0	0	57	
Total,	66	60	63	107	170	697,906	459,557

The States marked [*] made charcoal iron only.

In the preceding tables, an effort has been made to present some figures as to the present status of charcoal pig-iron manufacture, so that our readers may consider the influences which affect the special plants with which they are interested. The lessons which these figures present vary in their application to different localities, but we may call attention to the fact that the decadence of the industry, in some sections, is directly traceable to the wasteful methods employed, whereby five or six cords of wood are consumed to produce a ton of charcoal pig-iron.

We cannot expect that the *fancy* prices for charcoal iron which prevailed years ago will again be received, unless they be the result of political disturbances affecting all values for the application of labor. Modern appliances and economic methods have reduced the money value of all manufactories; similarly research and investigation has encouraged the application of chemistry and kindred sciences to metallurgy, and where quality has been the standard to be attained. efforts to secure this end have been continuous.

Competition must be met, and to do this the producer of charcoal iron must take advantage of all economical processes of manufacture; using not only labor-saving appliances at the mine or furnace, but carrying his efforts into the woodland, so as to secure the largest practical output of charcoal from a given amount of wood.

We close this review by extract from an editorial in the *American Manufacturer*, entitled:

"THE POSITION OF CHARCOAL PIG IRON.

"For many years, and, indeed, until quite recently, charcoal iron, not only in price but in quality, was the leading pig iron in this market. For all purposes that required a high quality, whether in castings or in rolled iron, it was considered necessary, and it still is a necessity in the manufacture of certain articles, as high-grade steel, car wheels and malleable iron castings, where any reliance is to be placed upon the product. The chief agent in reducing the comparative consumption of charcoal iron has been the introduction of the Bessemer process. Even in the early history of this process, charcoal iron was used, and it was for a long time believed that it was a necessity to make good steel; and even now, with all the improvements that have been made in the quality of coke iron, it is found that charcoal pig still makes a much better steel than coke pig, and that even where coke iron is used an admixture of charcoal iron greatly increases the wearing quality of steel rails, and renders them less liable to breakage. In connection with this latter statement it may be mentioned that the Chicago and Northwestern railway have for years been making tests in this line and have ascertained the facts to be as given.

"Under this substitution of coke and anthracite irons for those made with charcoal, there has been a gradual reduction in the difference between the prices of the irons made with mineral and vegetable fuel. * * * How great the difference in the two grades of iron in the past has been is shown in prices paid even as recently as 1880 for iron for car wheel purposes. At a foundry at one of the lake ports the charcoal iron that went into car wheels cost, delivered, $56 a ton, while coke iron of a high grade for car castings cost but $28—just one-half. Owing to various causes. not only this difference but the difference that is justly due to the increased cost of manufacturing charcoal iron, has been gradually removed, until it is reported that certain fair brands of charcoal iron have been sold in Chicago at a less price than coke iron of standard quality has brought in the same market. The cause of this great decline in the Chicago market, which of course, has had its affect upon the price of charcoal iron in other markets, has been chiefly the failure of certain parties holding large amounts of charcoal iron, and the forcing of this iron upon the market at sheriff's sale. The stocks so forced upon the market in Chicago are reported to have aggregated over 400,000 tons. This is an amount of charcoal pig iron equal to two-thirds of the total stocks of charcoal irons held in the west and south at the present time, and is equal to about a month's make of all the charcoal furnaces in blast at the present moment in the same territory. The effect of throwing as large an amount of iron as this upon the market to be sold at any price that it would bring, even though those sales might be scattered through a series of months, can be readily imagined. That result is, as indicated above, the reduction of the price of charcoal iron in the Chicago market to the price of standard brands of coke iron.

"The effect of these forced sales has in a measure passed away, but still the ruling price of charcoal iron, compared with the price of standard brands of coke iron, is not what it should be, in view of the difference in the cost of manufacture. * * *

"As the result of this condition of the market, furnace after furnace has gone out of the business; stocks have been materially reduced, until to-day they are at the lowest point they have reached since the middle of 1884, and the average production of the present year is not equal to the consumptive demand, if any judgment can be based upon the great reduction of stocks that has taken place in the last year. On the first of July, 1886, for example. the stocks at the Western and Southern charcoal furnaces were 142,014 tons; on the first of September of the present year, they were but 60,599 tons.

"It occurs to us from this statement of the facts that the charcoal iron manufacturers of the country have their business in their own hands, if they but choose to exercise even a moderate amount of wisdom and patience. For many purposes, charcoal iron must be used, and, as we have indicated above, the production is not up to the consumption, and the cost of making charcoal iron is constantly increasing through the exhaustion of the timber near the present location of furnaces The charcoal iron industry certainly has tarried long enough in its present depressed condition, and if these manufacturers will but have courage and wisdom, there are better days in store for it in the near future."

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The following is the production and value of some of the minerals produced in the United Kingdom in 1886, as compared with 1885:

DESCRIPTION.	MINERALS RAISED 1885.		MINERALS RAISED 1886.	
	Quantity. Statute tons.	Value at the mines.	Quantity. Statute tons.	Value at the mines.
Bog iron ore,	8,066	£2,420	6,780	£2,712
Clays (excepting ordinary clay),	2,531,198	600,934	2,390,440	583,210
Coal,	159,351,418	41,139,408	157,518,482	38,145,930
Cobalt and nickel ore,	100	422	100	562
Copper ore,	36,241	79,763	18,205	38,567
Gold ore,	35	7		
Gypsum,	112,078	47,753	118,848	44,462
Iron ore,	15,417,982	3,969,719	14,110,013	3,513,525
Iron pyrites,	29,870	18,517	27,829	16,575
Lead ore,	51,302	407,600	53,420	471,295
Manganese ore,	1,688	2,411	12,763	10,893
Ochre, umber, etc.,	13,328	23,459	12,392	22,185
Salt,	2,207,683	780,615	2,142,220	742,178
Slates and slabs,	468,954	1,175,772	456,208	1,107,169
Stone, etc.,	....	8,849,102	......	8,817,705
Tin ore,	14,376	662,390	14,232	780,302
Zinc ore,	24,668	67,000	23,156	63,759

ACCORDING to *Engineering*, it has been observed that the molten iron seen during a casting of several tons is transparent. It was possible to see bodies through the stream of metal, they taking, however, a yellow tinge.

Scraps of History.

A correspondent of the Ashland *Republican*, says of the old PACTOLUS FURNACE, situated on the Little Sandy River. Ohio. "The furnace was built on level ground, and in 1829 the stock was carted on an inclined bridge to the tunnel head.

The salt furnaces had abandoned salt making to a considerable extent, and sold their old salt kettles for whatever they could get. Mr. Richard Deering conceived the idea of putting up a small furnace or cupola for the purpose of working this class of scrap iron into hollow-ware, and built the furnace on a cheap plan, as he could work up all of the scrap in a few years, when he would have to use iron ore alone. He used some ore from the start. Afterwards ore was used altogether. The stack was 31 feet high and 7 feet at bosh, the tunnel-head plate 22 inches in diameter. The hearth was put in square, 5 feet high to where the bosh began and the bevel of the bosh 10 inches of the foot, the tuyere 18 inches high and the dam 14 inches high. The blast was made with two large wooden tubs 10 feet in diameter and 12 feet high, having but one head at the bottom, with valves, the water-wheel revolved, the shoving head descended, and that opened the valve into the other tub and raised its shoving head the same heighth, and this head was forced down with weights and that drove the blast to the furnace through wooden pipes, which passed through a leather boot with a nozzle on it to the tuyere.

"The tuyere was made of clay, plastered up with 'aspatsulen,' as it was called; the tuyere had to be made after every cast, at least it was seldom a tuyere made of clay would stand two castings when the furnace was full of melted iron. If the iron was suited for castings they'd 'quosh' the cinder off in front of the tymp and then put in a stopper under the tymp to keep back the cinder. When the iron was too bad for casting it was put into pig iron and sent to Hopewell forge, 3 miles below the furnace, to be made into bar iron. The amount of ore at each charge was from 250 to 400 pounds to 8 baskets of charcoal of 3 bushels each, and 10 pounds of limestone, for flux. The furnace ran some 40 charges in 24 hours. The ore yielded about 40 per cent. of iron and cost $3 per ton, charcoal about 3 cents per bushel. The cost of making a ton of iron was about as follows:

Cost of charcoal,	$11 52
Cost of ore,	7 40
Cost of running off,	3 00
Cost of lime,	40
Cost of moulding,	8 00
Total,	$30 32

Castings were worth some $50 per ton in Cincinnati. The great trouble was to sell, as there was very little good money, therefore it had to be traded for merchandise, in the way of dry goods and provisions, and as there was a store kept at the furnace and they could pay for all of their work in trade at large margins, it suited the company very well; but this community had a very serious time to get enough money to pay their taxes."

IN the *Chattanooga Tradesman* Prof. Henry E. Colton, describes one of the oldest furnaces in the Southern States, the old stack of the Knoxville Car Wheel Company, on Stony creek, in Carter county, Tennessee; called Carter Furnace, not from the fact that it was in Carter county, but because it was originally built and for many years owned by the Carter family, from whom the county was named. Prof. Colton says:

"The old stack has been many times repaired, but in it are still many of the original stones. It is 28 feet square at the bottom and 32 feet high. The blast has been from its beginning and is yet drawn from a clumsey pair of square wooden cylinders, but little improved from their first construction, and the power to drive them is furnished by a large slow-moving water-wheel. Yet in this "old rattle trap," as many would call it, have been made many thousand tons of pig iron of the very best quality. Its average make may be said to have been three tons per day, but it has made five tons and on exceptional days six tons.

"The location of this stack is on Stony creek, a tributary of the Watauga, about eight miles from Elizabethton, on the East Tennessee and Western North Carolina Railroad. Stony creek flows almost directly south for about ten miles, in a valley of varying width. This valley is mostly of limestone with large areas of drift. The mountains on each side are Potsdam sandstone and shaly slates of the same period. The sides of these mountains and the hills of the valley are the store-houses of immense bodies of iron ore of almost every known variety, and one or two varieties which are not of common occurrence.

"The ore from which the old Carter Furnace was supplied was derived from a bed near by of the limonite species. Of late years almost the entire supply has been gotten from the dirt by washing the large lump ore having become scarce, but in no way has the quality deteriorated. For many years it was the sole iron used by the Knoxville Car Wheel Company in making its car-wheels, and through it the wheels made by that company attained a widespread and high reputation.

"This ore contains a small percentage of zinc, and in working a condensation of the zinc vapor takes place around the throat at the top and a ring is there formed, which has to be cut away several times during some blasts. The ore also contains some cobalt· which forms irrepressible balls in the furnace, which are very troublesome. In the main, however, the ore is very pure and can be so selected in the mine that nearly all the above troublesome matters can be left out. This bed of ore has been drawn on to supply forges and furnaces for fully seventy years. For many years the ore was hammered into bars or blooms in an old-fashioned forge, the iron being hauled over the country for hundreds of miles, and traded for bacon, corn and wheat. When the furnace was erected the scrap and some pig metal were still worked in the forge, and this was continued up to a late day, but the greater part of the iron made was cast directly from the stack into hollow-ware of every variety, and much of this was hauled to the river and boated down the Watauga, and thence on to the Tennessee, and even to New Orleans. These castings had a high reputation for toughness.

"The ores of the Stony Creek valley lie on the sides and the foothills of the Iron, Holston and Cross mountains. The chief rock shown toward the top of these mountains is the Potsdam sandstone, it sometimes reaching far into the valley. Along its lower border there is almost constantly a peculiar ore of iron, ranging from fifty to fifty-five per cent. of metallic iron, but containing about fifteen per cent. of silica and four-tenths of one per cent. of phosphorus. One great singularity of it is that the silica is in grains of crystallized sand of some size and can be washed out easily by crushing the ore. The amount of this ore in this valley is immense, and while it is never likely to be used to make a car-wheel iron the day will come when it can be shipped elsewhere and for other uses. In many places this vein is from five to seven feet thick. At intervals in the neighborhood and just below this ore are found beds of limonite of great richness in iron but containing a large quantity of phosphorus. The most easily fluxed ore I ever saw, and of wonderful fluidity. While running No 2 furnace on it I one day stuck a knitting needle down in a pig bed, making a hole in the sand just its size. After the cast was made a cast iron knitting needle, perfect in every respect, was found under the pig. The iron from this ore, as also from the silicious ore above, was extremely soft, but had no strength. A small hammer would batter it almost like lead, while one moderate blow from a sledge broke it easily. Below these ores, in a yellowish and reddish shaly slate formation, is found, in a lenticular vein, an ore resembling the best Pilot Knob. It contains about 60 per cent. of metallic iron and no phosphorus. It occurs steadily in its place on the sides of the mountain, varying in thickness from a foot or two to six, eight and even ten feet. It is not massive but comes out in shapes square and rhomboheclral. The quantity of it in this valley is very great, and singularly no effort has been made to use it in the furnace. The excuse was that it was harder to melt than the other ores. In the forge it made a very superior iron. Below this ore are some of the above shales; then come, in contact with the limestone, the limonites heretofore spoken of.

"For some time this furnace has been idle, and probably will continue so until the stack is rebuilt.

"Just as the traveler enters the wild gorge of Doe river beyond Elizabethton a careful look reveals to him, a little below the elevated road bed, an old furnace stack, from the top of which several good-sized trees spring forth and flourish. As it stands there, a memorial of days long gone by, picturesque in the wildness of its location, with vine-covered sides and tree-covered top, it is a fit subject for the artist's pencil and a powerful lesson of the grand progress which iron manufacture has accomplished."

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A late attempt to produce rolled steel car wheels at Chicago is described as casting blanks of steel, an inch or more in diameter than the finished wheel, and then compressin the tread and flange by rolls acting against the wheel while it is held in a horizontal position.

The New Iron Ore Districts of Lake Superior.

In the last issue of the JOURNAL, pages 155 to 166, the Gogebic iron Range in the States of Wisconsin and Michigan was discussed and additional data promised which we now offer.

The ores in the Gogebic Range differ from those of the Vermilion range in Minnesota in being softer, and, therefore, more easily mined, yielding less iron and also less phosphorus, but carrying a greater percentage of manganese, and more moisture. The dip of the Vermilion ore is nearly vertical; that of the Gogebic ores approximates 70 degrees.

The apparent extent and continuity of the Gogebic deposit has encouraged the formation of a large number of mining companies to which reference has been made on page—, many of which must either be consolidated or stand the test of the survival of the fittest. There are, however, some truly remarkable openings along the range, and notwithstanding the apparent continuity of the ore body, it is probable that the bulk of the shipments from the Gogebic Range will, as in the Marquette and Menominee Ranges, come from a few large mines. Of the total amount of ore shipped to the close of 1886, namely, 877,069 gross tons,

The Colby mine supplied,	**342,766 gross tons.**
The Norrie mine "	**140,263 "**
The Aurora mine "	**98,802 "**
The Ashland mine "	**80,486 "**
Making a total of,	**662,317 gross tons,**

or 75.7 per cent. of all the ore shipped up to the close of 1886. These four mines will be the largest producers in 1887, but several others will be added, which may approach the output of the Aurora mine in 1886.

The following analyses are presented to show the general composition of some of the Gogebic ores (when dried at 212°:

	IRON KING.		NORRIE.		AURORA.	ASHL'D.	GERMANIA.	
						48 cargoes.		
Iron,	60.85	55.74	63.57	62.83	62.93	64.50	59.38	59.70
Phosphorus,	0.027	0.034	0.06	0.0474	0.0278	0.047	0.058	0.056
Silica,	5.44	3.47	4.09	5.18		3.65		
Manganese,	1.30	12.28						

	PABST.			SUPERIOR.				
Iron,	58.47	58.46	58.38	62.36	64.83	65.18	64.25	59.30
Phosphorus,	0.040	0.044	0.036	0.06	0.047	0.40	0.054	0.079

COLBY MINE.

	North Vein [?].	South Vein [?].			
Iron,	59.50	60.00	58.61	59.30	57.736
Silica,	2.50	2.30	3.89	3.55	6.863
Phosphorus,	0.043	0.043	0.05	0.039	0.047
Manganese,	3.00	4.50	. .	. .	1.919

MONTREAL MINE.

Iron,	56.00	65.22	65.35	66.00	66.50	67.65
Silica,	1.40	3.45	2.80	1.72	1.30	1.20
Phosphorus,	0.028	0.038	0.045	0.041	0.031	0.046

The Gogebic ores carry, on an average, about 60 per cent. of iron when dry, some of the mining being above that figure. Carelessness in mining, particularly in open pits, is almost invariably followed by a decline in the iron-contents. Although the ore from a few mines is almost too high in phosphorus, the average product of the district is Bessemer ore. The ore carries about 13 per cent. of moisture in the winter, sometimes running as high 15 per cent., while in the summer it is from 4 to 5 per cent. less, averaging 7 to 10 per cent. The furnace-averages of a number of analyses of ore from mines which are large producers are as follows:

MINE.	Iron.	Phosphorus.	Manganese.
Anvil.	60.00	0.05	
Ashland, 1888,	64.00	0.04 to 0.05	
Ashland, 1887,	61.00	0.04 to 0.05	
Aurora (open pit),	57.00	0.035 to 0.04	
Colby,	60.00	0.045	3.00
Germania,	60.00	0.05	
Iron King, north vein,	61.00	0.03	
Iron King, south vein,	58.00	0.04	4.00
Ironton,	61.50	0.045	
Kakagon,	60.00	0.05 to 0.06	
Norrie,	62.00	0.05 to 0.06	
Pabst,	57 to 61	0.035	1.00
Puritan,	61.25	0.045	
Sunday Lake,	61.00	0.04	

The days of exceptionally cheap mining in the Gogebic range are over. Large quantities of ore have undoubtedly been taken from open cuts at low figures, but by the close of the year few if any of the mines will be operated in this manner. The royalty is also a continued and heavy charge upon the profits.

From present development, it would appear that the ores of the Vermilion range can be mined as cheaply as those of the Gogebic range. The former require more labor and explosives, but the ore forms its own supports; the latter are soft, and while more easily removed, demand expensive timbering, and it may be necessary, to secure permanent work, to sink the slopes in the foot-walls. The amount of water to be raised is, with a few exceptions, remarkably small considering the territory covered by these two ranges.

A long pause followed in the development of the Marquette and Menominee regions, and American capital began to look in the direction of Canada for new sources of Bessemer ore-supply, when almost simultaneously, in 1884, the Gogebic and the Vermilion ranges sent their first cargoes of ore to market.

By the opening of the new districts the question of a full ore-supply for years to come is secured to the entire iron and steel industry west of the Allegheny mountains and probably further east.

VERMILLION IRON RANGE.

Although the existence of the deposit of ore in the vicinity of Vermilion Lake, Minnesota, had been reported for about twenty years, no active efforts looking towards its utilization were attempted until 1883, when the first real work was done. Now, after a lapse of four years, there are excavations from which over 850,000 gross tons of iron-ore have been taken; a railroad constructed, extending through the forest for 70 miles to Two Harbors and continuing 26 miles further along the lake shore to the city of Duluth; and over 5,000 people living around the mines and dependent upon the 1,300 men engaged in extracting the ore from them.

The first shipment of ore from Two Harbors was made on August 1st, 1884, but before the close of navigation of that year, 62,124 gross tons had been sent forward by lake vessels to various blast-furnaces. That the quality of Vermilion ore sustained the reported analyses, is evident from the fact that the shipments in 1885 more than trebled those of 1884, the gross amount for 1885 reaching 225,484 gross tons. In 1886 this was still further increased and 304,396 gross tons were shipped. Contracts for freight covering 400,000 tons have been made for the present year; and by the close of navigation, an aggregate of over 1,000,000 tons will have been taken out of the mines in the vicinity of Tower, all of which yielded 62, and much of it 68 per cent. of iron, and nearly all of it shipped has been within the Bessemer limit of phosphorus.

A personal examination of all the analyses (115 in number) taken from a stock-pile of 165,000 tons showed an average of iron 67.7; phosphorus, 0.06; silica, 1.5. The range of the entire series of analyses was found to be iron, 65.29 to 69.28; phosphorus, 0.049 to 0.067; silica, 0.68 to 3.79. Several analyses show over 69 per cent. of iron, indicating that the ore closely approximates the theoretical purity of red hematite. The extreme range of phosphorus found in analyses since the opening of the mines to date is reported as from 0.028 to 0.11, but the ore as mined shows from 0.04 to 0.07 of phosphorus. Mr. F. Prince, mining engineer for the owners of the mines, furnishes the appended analyses.

To reach the Vermilion iron-ore region the Duluth and Iron Range railroad skirts the northern shore of Lake Superior, from Duluth to Two Harbors, where shipping-docks, with a capacity of 14,000 tons, and the railroad settlement are placed. From Two Harbors the road follows a general north-west direction, rising in the first 3 miles 400 feet, and in the first twelve miles 1,100 feet, to the summit of what might be called the coast range, then crossing the drainage area of the St. Louis river to the Messaba range, a ridge of granite, where explorations are now in progress for magnetic ores. Continuing 15 miles beyond the Messaba range the Vermilion iron-ore mines are found at an elevation of 900 feet above Lake Superior. The openings indicate a number of ore-lenses of large size lying on two nearly parallel hills, but ore has also been found in wells sunk between the two ridges, and explorations with the diamond drill are now in progress in the intermediate territory. These lenses, as developed, are known by various names; the Breitung mine, the most westerly opening, has produced over 62,000 tons of ore; next to and adjoining this opening is the Tower No. 1, which is an excavation 250 feet in length, 180 feet in width, and 100 feet deep, from which nearly 215,000 tons of ore have been taken. Immediately adjoining this the Tower No. 2 mine shows a length of 220 feet, a width of 60 to 80 feet, and a depth of 100 feet; it has produced over 170,000 tons of ore.

Between the Tower mines and the Ely opening there is some unexplored ground. From the Ely pit, which is 400 feet long and 50 feet wide, over 88,000 tons of ore have been taken; and immediately adjoining the Ely is the Stone pit, 700 feet long and 100 feet deep, showing a width of 50 feet, which has produced nearly

240,000 tons of ore. The most easterly excavation is the Stuntz mine. 250 feet long, and from 20 to 50 feet wide, from which about 25,000 tons have been raised. These six openings are on one ridge and cover a strike of about one mile. On a second ridge two openings known as the Lee mines have produced about 50,000 tons of ore. All of these workings have been open quarries, but at present preparations are being made and shafts sunk for underground operations.

The ore being hard and dense, lying practically free from any foreign material, except the generally well-defined seams of jasper and "soap-rock," demands the use of rock-drills and high explosives; but as comparatively little must be taken out beside the ore, the cost for explosives per ton of ore is less than is generally estimated.

Analyses of the Vermilion iron-ores made by Mr. Prince show:

Iron,	67.99	68.37	68.32
Phosphorus,	0.053	0.057	0.046
Silica,	1.35	1.10	1.35
Alumina,	undetermined	0.50	0.25
Magnesia,	undetermined	0.014	nil.
Sulphur,	0.005	0.007	nil.
Loss by ignition	undetermined	0.56	0.66

In a country overgrown with timber and cut up by swamps and lakes, prospecting naturally proceeds under difficulties, and it may readily be perceived that many important deposits still remain undiscovered. The development of a property such as that described has naturally encouraged exploration of adjacent territory, and some very satisfactory discoveries have been made about 20 to 40 miles to the east.

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A CASE of some interest to our readers is that of a collier who sued one of the Alabama furnace companies (his former employer), for breach of contract in discharging him from their service. He was employed to make charcoal on a wood tract of the defendant's, and they answered that he had been discharged for drunkenness and neglect. In this case the court charged the jury that the fact that the plaintiff was drunk once or a number of times, at the furnace or elsewhere, during his employment under the contract, is no evidence against plaintiff's recovery unless it appears to the jury from the evidence that such drunkenness incapacitated and caused the plaintiff to fail in his part of the contract. Plaintiff had judgment and defendent carried the case to the Supreme Court of Alabama, where the judgment was reversed. Judge Somerville, in the opinion, said: "It was shown that the plaintiff was drunk on the premises of defendant, about 4 miles from 'the coaling,' and whilst intoxicated raised a disturbance and got into a fight with a man; and that at another time he was drunk in a wagon, going toward the 'coaling.' To justify an employer in discharging a servant he must show that there was a breach of some express or implied provision of the contract of service. But it seems, now, to be fairly settled that it is an implied part of every contract of service that the employee will abstain from habitual drunkenness or repeated acts of intoxication, during the employment. We do not doubt that the public drunkenness of an employee manifesting itself in boisterous and disorderly conduct toward his employer or third person, is such misconduct as to justify his discharge; and we think, too, that for a single act of drunkenness, with such characteristics, the employee may be discharged; the charge was clearly wrong and the judgment must be reversed."

Boshes in Blast-Furnaces.

In *Stahl und Eisen*, F. W. Luermann, a German metallurgist, after considering the conditions governing the descent of the materials forming the charge in blast-furnaces for boshes of different degrees of inclination, states that the shape of the furnace may be improved by omitting the boshes entirely, as in practice they are soon melted away, and the lower part of the furnace becomes substantially cylindrical. In illustration of this opinion a furnace was built and blown in at Müsen in August, 1885, and kept in blast until December, 1886. The furnace, of 31 feet 8 inches total height, is 3 feet 9 inches broad at the throat and 4 feet 1½ inches at the bottom. The lower part of the stack is cylindrical for 4 feet 2 inches, and above that level is slightly conical, the slope of the side being about 9° from the vertical; the cubical content is 353 cubic feet. During a blast lasting 460 days, the total make was 2,781.4 tons of pig iron, or an average of about 6 tons in 24 hours, so that the effective volume per ton of daily make was only 59 cubic feet as compared with 166 cubic feet in the larger German coke furnaces, and 350 cubic feet and upwards in those of the Middlesboro' district. The consumption of charcoal was at the rate of 22¼ cwt. per ton of iron made from a mixture containing 46.9 per cent. of iron. The make was principally gray, mottled, and white charcoal iron of the highest quality for use in making chilled rolls and malleable castings. After blowing out, the sides were found to be burnt out to a considerable extent in the region of the hearth and tuyers, showing that there is no tendency to the formation of scaffolds in these parts, and, therefore, that the boshes are unnecessary.

Mr. W. J. Taylor, a member of the Association, made a costly experiment with a straight, or no bosh, furnace at the Chester furnace, N. J., and his results were freely given in a paper read before the American Institute of Mining Engineers, and referred to in the JOURNAL, Vol. 7, page 94.

◆

AT the Newcastle Exhibition, England, Messrs. Bolckow, Vaughan & Co. showed a model of a blast furnace with hot blast stoves, &c., complete, made to a scale of ¾ inch to a foot. This furnace has a bosh of 24 feet diameter, crucible 10 feet, throat 13 feet; the height of the furnace being 93 feet, and the yield of Cleveland pig iron 520 tons per week.

The average type of Cleveland furnace in actual practice at the present time is about 80 feet in height, and 23 to 25 feet bosh.

At Ferryhill, there are furnaces over 100 feet high, and this district has attained the honor of building the largest furnaces in the world.

The output of iron in the north-east district of England may now be put down at 2,500,000 tons annually, but an increased quantity of this is obtained from the rich ores imported from Spain and the south of Europe. The output of iron stone from the Cleveland mines is 6,000,000 tons annually.

Messrs. Bell Brothers, limited, made a display of the materials employed in the Cleveland iron manufacture, and they illustrate the exact quantities required to produce a ton of iron. The quantity of air blown into the furnace at ordinary atmospheric pressure is set down at 165,000 cubic feet, equal to a cube of 55 feet on a side, and weighing 104 cwt. after being heated by the waste gases resulting from the combustion of the fuel to a temperature of 1,000 degrees. The gas amounts to 216,000 cubic feet, or a cube of 60 feet on a side, at ordinary temperature, and atmospheric pressure, and weighs 139 cwt. A summary of the contents of the furnace shows that the following materials are charged for one ton of pig produced: Air (nitrogen, oxygen), 104 cwt.; iron stone, 47 cwt.; fuel, 22 cwt.; flux, 11 cwt.: total, 184 cwt.; and there came out of the furnace: gas (nitrogen, carbonic acid, carbonic oxide), 139 cwt.; iron, 20 cwt.; slag, 25 cwt.; total, 184 cwt.

◆

THE following statement shows the French production of iron and steel during the past year, compared with that of 1885, in detail:

PIG IRON.	Forge pig. Tons.	Foundry pig. Tons.	Total. Tons.
	1885.		
Coke pig,	1,235,364	350,100	1,585,464
Charcoal pig,	21,710	7,405	29,115
Mixed brands,	. . . .	16,069	16,069
Totals,	1,257,074	373,574	1,630,648
	1886.		
Coke pig,	1,188,605	298,309	1,486,914
Charcoal pig,	7,958	4,327	12,285
Mixed brands,	. . . . .	8,651	8,651
Totals,	1,196,563	311,287	1,507,850
Difference for 1886,	60,511	62,287	122,798

MANUFACTURED IRON.	Rails. Tons.	Merchant iron. Tons.	Plates. Tons.	Totals. Tons.
	1885.			
Puddled iron,	4,479	556,525	102,106	663,110
Charcoal iron,	. . . . . .	17,666	6,830	24,496
By reheating,	256	84,811	9,758	94,825
Total,	4,735	659,002	118,694	782,431
	1886.			
Puddled iron,	910	569,109	88,485	658,504
Charcoal iron,	. . . . .	13,527	4,241	17 768
By reheating,	. . . . .	82,972	7,970	90,942
Total,	910	665,608	100,696	767,214
Difference for 1886,	3,825	+6,606	−17,998	−15,217

The Iron Ores of Tennessee.

The Executive Committee having accepted an invitation to hold the Eighth Annual Meeting of the United States Association of Charcoal Iron Workers at Nashville, Tennessee, we give space to the following data of that State, excerpted from the fourth coming report upon Mineral Resources by the United States Geological Survey.

"The production of iron and the mining of iron ores is not a new industry in Tennessee, although the rapid development in late years has brought this State more prominently before the public. Some of the older iron works of the State have a reputation for their iron, for special purposes, recognized all over the country, and the abundance of the ores of iron and their variety give promise of continued activity in iron production and manufacture. Concerning the iron ores of Tennessee, Mr. J. B. Killebrew, in a monograph entitled 'Iron and Coal of Tennessee,' says: 'There are four distinct belts or areas of iron ores in the State, occupying in whole or in part forty-four counties.

"(1) The Eastern iron-ore belt, extending through the State and lying in front and at the north-western base of the Unaka mountains, along which range passes the line between Tennessee and North Carolina.

"(2) The Dyestone belt, skirting the south-eastern base of the Cumberland table-land from Virginia to Georgia, spreading out laterally for a distance of from 10 to 20 miles into the valley of east Tennessee.

"(3) The Cumberland table-land, co-extensive with the Coal Measures of the State, and extending into Kentuckey and Alabama.

"(4) The Western iron belt, lying west of the central basin, generally east of the Tennessee river, in its reflex course through the State, though overleaping that stream and appearing in west Tennessee.

"The Eastern belt is noted for its pockets and seams of brown hematites, and some unique red hematites; the magnetic ore which is strongly developed at the Cranberry mines, North Carolina, also extends into Tennessee. A limited iron-producing industry has been sustained for many years on the ores of the Eastern belt, both as blast furnaces and as Catalan-forge fires. The following are analyses of some of the brown hematites used at the charcoal blast furnaces:

Analyses of brown hematites from the Eastern belt of Tennessee.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron,	50.41	47.66	49.86	46.56	57.33	56.19
Combined oxygen,	21.11	20.07	20.97	19.73		
Silica,	8.38	12.05	7.18	13.61	6.15	3.08
Water,	12.50	12.50	12.84	12.36	9.13	14.00
Phosphorus,	.12	.13	.17	.16	.00	.312
Alumina,	6.47	6.84	8.11	6.90	.28	
Lime,	.18	.10	.19	.009	.92	
Sulphur,	....	....	....	.21		
Total,	99.17	99.44	99.32	99.539	73.81	73.582

Analyses of the same brown hematites after washing and roasting.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Silica,	3.06	9.550
Sesquioxide of manganese,	3.27	
Peroxide of iron,	82.27	77.44
Metallic iron,	57.60	54.92
Phosphoric acid,	.09	.008
Alumina,	1.28	
Sulphur,	.20	
Phosphorus,	.039	.044

"The Dyestone or Clinton belt consists of several nearly parallel strikes, extending from 70 to 150 miles through the eastern section of the State, and the ores are found near the northern boundary, as well as close to Chattanooga. The thickness seldom reaches 3 feet, although there are localities where the ore shows 7 feet.

"Mr. H. S. Fleming, in a paper on the ores used in the Chattanooga district (Transactions of the American Institute of Mining Engineers, Vol. XV), says: 'Ore mined at Rockwood, Roane county, Tennessee, gives iron, 43.47 per cent.; silica, 9.66; alumina, 5.23; carbonate of lime, 19.14; phosphorus, 0.574.'

"A sample of this ore mined by the Roane Iron Company and sampled from the stock pile at the furnaces, gave iron, 48.36; silicia, 14.78; phosphorus, 0.63 per cent.

"The ore from Rockwood, Tennessee, is a soft micaceous hematite, locally called specular ore, When cleanly and properly mined it averages as shown in the analyses. It is self-fluxing in the furnace, easily reducible, and carries a comparatively low percentage of fine material. The outcrop of this ore shows no lime, but after mining to any considerable depth the lime increases, and finally the iron runs out altogether, and is replaced by lime.

Composition of Tennessee River soft fossil ores.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Iron,	45.35	44.50	43.37
Alumina,	11.12	9.89	10.13
Silica.	12.51	15.94	14.19
Phosphorus,	.610	.816	.73

The soft ore, as delivered, is of a rusty, brownish color, and carries from 20 to 60 per cent. of fine dirt ore. In wet weather it contains as much as 30 per cent of water, and is very sticky and hard to unload The variation in the ore is mostly due to moisture, though at times an excessive amount of slate accompanies it."

Analyses by Professor McCreath of ores taken from stack piles at the Chattanooga furnaces show the following composition when dried at 212° F.:

Analyses of red (dyestone) ore, Clinton formation No. V, in Tennessee.

	SOFT FOSSIL ORE.		Hard fossil ore.
	No. 1.	No. 2.	
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron,	44.700	49.150	26.600
Phosphorus,	.429	.607	.388
Siliceous matter,	19.760	14.480	8.210
Phosphorus in 100 parts of iron,	.959	1.235	1.458
Lime (CaO),	.....	. . .	27.000

Dr. John B. Porter, in a contribution upon "The Iron Ores and Coals of Alabama, Georgia, and Tennessee," to the Transactions of the American Institute of Mining Engineers, Vol. XV, gives numerous analyses of the red fossil ores of Tennessee, of which the following are typical:

Analyses of the red fossil iron ores of Tennessee.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica,	14.81	20.70	9.70	9.64	14.50	4.00
Iron,	43.39	40.82	50.20	50.14	50.00	57.04
Phosphorus,	.633	.607	.580	.582	Trace.	.042
Carbonate of lime,	.....	.....	5.36	8.14		
Alumina,	2.47	9.04	5.86			
Water,	7.71	6.30	. .	9.13	11.90	13.00
Sulphur,	.....	.....	.....	. . .	. . .	.46

The Cumberland table-land belt produces carbonates, such as kidney or flag ores, but they are used to only a limited extent.

Analyses of the Tennessee River hard fossil ores.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Iron,	33.40	31.42	29.60
Carbonate of lime,	31.85	34.68	40.32
Silica,	6.79	7.49	5.64
Phosphorus,	.614	.520	.438

"The hard river ore, mined in many cases close by the soft, is, as its name indicates, a tough ore, hard to break. The amount of lime it contains is very unreliable; anywhere between 23 and 40 per cent. of carbonate of lime."

Mr. Killebrew says in his report: "In three samples of Rockwood ore, Nos. 1 and 2, from tunnel No. 3, from the surface, the increase of lime near water level is very apparent."

Analyses of carbonate ores from Rockwood, Tennessee.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Silica,	4.50	5.50	6.50
Water,	1.50	2.60	4.00
Alumina,	2.80	2.60	3.40
Lime,	16.30	16.35	1.60
Metallic iron,	41.43	39.00	56.88

The above may be truly taken as a fair showing of the ore of the shin-bone seam throughout its length. On the surface it is rich in iron; near and below water level it contains a large quantity of carbonate of lime and much less iron.

The western iron-ore belt is very interesting as producing large quantities of excellent brown hematite ores. It includes the counties of Stewart, Montgomery, Houston, Humphreys, Dickson, Perry, Hickman, Lewis, Wayne and Lawrence an the east side of the Tennessee river, and Benton and Decatur on the west side. Its topography is varied, being a slightly rolling plateau, traversed by numerous streams, which cut down through the strata, having an average elevation of about 1,000 feet above the sea level. Mr. Killebrew also remarks that "most of the beds of ore in this belt, taken as a whole, may be classed as limontine, though large bodies of goëthite exist. Turgite is chiefly found in layers or as the interior linings of hollow concretions. Streaks and specimens of red ore are found in many beds of limonite, being a very pure variety of turgite, nearly anhydrous." These ores are smelted largely with charcoal, and the amount of iron so produced is yearly augmented in this district. The following are some analyses of ores from the western iron-ore belt:

Analyses of ores from the western iron-ore belt, Tennessee.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Metallic iron,	57.85	58.21
Oxygen with the iron,	24.37	24.88
Water,	11.96	11.06
Insoluble siliceous matter,	3.59	3.21
Soluble silica,	.78	.13
Sulphur,	None.	None.
Phosphoric acid,	(*a*).54	(*b*).36
Alumina,	.13	.39
Lime,	.05	.17
Magnesia,	.03	.06
Manganese, undetermined matter, and loss,	.71	.42
Total,	100.00	99.89

a Phosphorus, 0.24. *b* Phosphorus, 0.16.

Partial analyses.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron,	46.49	57.50	53.17	53.72	59.86
Insoluble siliceous matter,	18.36	3.90	10.01	3.73	3.35
Sulphur,	None.	None.	None.	None.	None.
Phosphorus,	.371	.201	.136	.084	.041

The following is ore from White county:

Analyses of iron ore from White county, Tennessee.

	Per cent.
Water,	6.09
Silica,	9.31
Iron,	48.58
Oxygen combined,	20.82
Sulphur,	.10
Phosphorus,	.29

One of the ores employed in the older charcoal iron works, and for the product of which a superior reputation was secured, is represented by the annexed analyses:

Analyses of iron ore from the Cumberland Iron Works, Tennessee.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Metallic iron,	57.84	59.22
Oxygen with the iron,	24.37	24.88
Water,	11.96	11.06
Insoluble siliceous matter,	3.30	3.21
Soluble silica,	.78	.13
Sulphur,	None.	None.
Phosphoric acid,	.54	.36
Alumina,	.13	.49
Lime,	.05	.17
Manganese,	.03	.06
Loss,	.80	.42
Total,	100.00	100.00
Phosphorus,	0.24	0.16

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Edited by JOHN BIRKINBINE, Secretary,
No. 25 N. E. City Hall Square. (N. Juniper St.),
Philadelphia, Pa.

ARTICLE V.—Constitution of the United States Association of Charcoal Iron Workers.

Any person practically engaged, or interested, by reason of capital invested, in making or using pig iron or blooms made with charcoal may become a MEMBER of the Association by paying an annual fee of five dollars ($5): *Provided,* That each iron works represented shall pay not less than ten dollars ($10) per annum into the treasury.

Persons not engaged in making or using charcoal pig-iron or blooms may become ASSOCIATES, without the right to vote or hold office, upon the payment of an annual fee of five dollars ($5) each. All fees to be due when the membership is applied for, and thereafter on the first day of October in each year, being in advance.

All communications should be addressed to the Secretary of the Association.

Physical and Chemical Tests of Pig Iron as Applied in Practice.

By H. S. FLEMING, A. C., *Philadelphia*, and W. J. KEEP, C. E., *Detroit, Michigan.*

[Read at the Eighth Annual Meeting of the United States Association of Charcoal Iron Workers, Nashville, Tennessee, November 15th, 1887.]

The tests usually made of pig iron are the breaking of a bar cast from the pig, either by a weight applied transversely or by a tensile strain. But little confidence is placed in the records of such tests for the reason that from the nature of the case, the conditions under which the test bar was made were not alike in different instances. The most important variation next to the method of remelting and casting, is the size of the bar. The same iron ordinarily will produce a very open grain if the casting is quite large, but a close grain if the casting is small. The smaller casting will probably be the stronger,

If possible, it would be very desirable that if a system of testing syould be devised which can be easily used by every founder with expedition. For example, if during one day's cast, some peculiarity is noticed in the mixture of iron used, it would be desirable before the next day's heat was made, that the irons could be tested and the undesirable quality counteracted. Also, if we could have common standards of strength, shrinkage, elasticity, chill, fluidity, &c., or as it were, a common language by which we could describe an iron, so as to be at once understood by both seller and buyer. Such a system should be used in all countries to secure the best result, so that we could read statements and know what were the conditions under which each test was made.

For several years we have been perfecting a system of testing which we shall be pleased to describe in detail, to anyone specially interested in the matter, and as soon as practical we hope to publish such a detailed description as will enable anyone to use this method. To awaken an interest in this subject, we will at this time briefly give a general idea of the character of the test.

A simple furnace using coke, and driven by fan blast melts in a covered No. 16 plumbago crucible, a fifteen pound sample of the iron to be tested. This can be done in thirty-five minutes, and from six to twelve heats taken in ten hours. The moulds are made of sand that has been used in the foundry, but which has no facing mixed with it, and is tempered as dry as will permit of it being worked easily.

The test bars are:

For Fluidity—A strip six one-hundredth inch thick, one inch wide and twelve inches long, is poured from the end before any other bars are cast. This never runs full and the length of the casting in inches is the fluidity.

The Crook Strip is a duplicate of the fluid strip with a rib on one side and the bend caused by the rib shows the internal strain due to thin and thick parts of a casting.

The Main Test Bars are twelve inches long and consist of a pair, one one-half inch square, and the other one inch wide, and one-tenth of an inch thick. These are cast together from one gate and a chill, bedded in the mold, lies so that each end of each bar runs against it making the length of the *mold* exactly twelve and one-eighth inches long. A shrinkage of one-eighth inch to the foot would therefore make the bars twelve inches long. Six of these pairs of main-test bars are cast from the fifteen pound sample. The *shrinkage* of each of the thin and each of the square bars is measured to get a true average. The apparatus for measuring shrinkage as well as for the manipulation of the casting is simple and very accurate, but cannot well be described in this short paper. Three of the square bars are broken to find the average *weight* that will produce *transverse fracture.* The other three square bars are broken by blows to find *resistance* to *impact.* The *chill* is determined by splitting the ends of one or more of the half-inch square bars.

The *grain* is examined by a lens of one-half inch focus and the appearance of the chill as well as the surface of the casting noted, peculiarities being recorded. The *deflection* is measured in all bars, and in those broken by impact, in addition to deflection, the amount of recovery at each blow is noted.

After constant use for over two years in a foundry melting about seventy tons of iron per day we have found the above described tests all that can be desired, as they show accurately what a founder needs most to know. By their use only such iron is bought as is adapted to the work, and each day's casts can be made to be exactly what is desired. Any peculiar result in a heat can be traced at once to the cause.

The reasons for deciding upon the half-inch square bars were that this size is large enough not to be influenced by the mould so far as grain is concerned, and the mass is sufficient to produce a grain which is representative of the iron. The bars are easily handled, and readily stored away, which is desirable, as no test should be destroyed, but all of the sets of bars should be kept for future reference. A half pig of iron is willingly furnished by any furnace as a sample. The freight and trouble of handling a half pig is but slight, and with this half pig *three* tests can be made and a sample will remain for preservation. One, and sometimes more, tests are unsatisfactory and it is not best to start with less than fifty pounds of any particular iron. If however only five pounds of iron are obtainable this is enough to run four pairs of square and flat bars, and a fluid and crook strip. This gives reasonable averages, and is useful to make the test of any particular casting which is in dispute. For purposes of original research, with rare materials, all that could be desired can be obtained by these bars.

Perhaps the strongest argument in favor of the half-inch square bars is the special testing machinery that can be employed. The size being uniform and the range being only six hundred pounds the most accurate apparatus of the simplest construction can be used and made for small cost. This is important if the use of the method becomes general. for the machinery is so constructed that but a few moments are occupied in any one test.

The *hardness* of each bar will be hereafter determined on Professor Turner's machine, one of which was received from Birmingham, England, a short time since.

For Transverse Break, With Weight—A fifty pound weight is run out on a single steel beam, the same propelling gear moving the diagram paper through one-fourth the distance traversed on the beam, thus recording automatically, the weight and deflection at every point.

For *measuring impact*, the machine works peculiarly. A twenty-five pound swinging weight delivers the first blow equal to a straight fall of a half inch. Blows are then rapidly struck, increasing the fall one-eighth of an inch with each blow, until fracture occurs. The same appliance is used to make the diagram as in the other machine but two pencils are employed. One recording the deflection at each blow, the other the recovery of the bar, and also showing the number and force of blows. To reduce the blow to pounds avoirdupois for comparison, we took the purest Swedish charcoal pig-iron to be had at the time, and broke three bars on each machine, viz: the "dynamic" and the "static." As the *weight* was two hundred and eighty-eight pounds, and the *blow* was from a fall of two and one-eighth inches, the foot pounds developed by such a fall of the twenty-five pound weight, was called two hundred and eighty-eight pounds; from this was calculated the value of each one-eighth inch fall. The reason for beginning at one-half inch is to be certain of being below the breaking blow of ordinary weak irons. As a blow for each one-eighth inch above, is struck, all samples are treated alike. This is so far as we know the most perfect test for impact made.

The strains to which castings are subjected are transvere, the effect of a weight or of a blow. Tensile strain is not one to which cast iron should be subjected, and compression need not be calculated except for columns, projectiles or rolls.

If the use of these tests could become universal, then records made in one part of the country would be as intelligible to a person in another part as to the one who made the test, and information could be exchanged.

So far as the real chemistry of pig iron is concerned, we know comparatively little, occasionally some experimenters have opened new doors, but for some reason they have never entered very far, we know generally the influence exerted in pig iron by different elements, but we do not know much about the reasons or conditions.

Unfortunatly metallurgical books which tell us more than that remelted pig iron is cast iron, are rare, they usually volunteer the information that sulphur makes iron "red-short," and phosphorus makes it "cold-short." Dr. Dudley, in his paper on the constitution of cast iron (Notes on the Constitution of Cast Iron, by C B. Dudley and F. N. Pease, Transactions of the American Institute Mining Engineers. February, 1886,) is inclined to think that iron carbide is the most important feature, but he adds: "There are very many interesting questions which might be asked and undoubtedly occur to all, answers to these questions will have to be obtained by further study," again he says: "It is earnestly hoped that study will be put on this interesting problem. The commercial results connected with it are something enormous. Some furnaces uniformly make strong irons, others uniformly weak irons," again he says: "We are confident that the man or men who first explore this field and give us a complete understanding of the constitution of pig iron, as well as a method of controlling its composition, will certainly cause iron metallurgy to take an enormous stride forward."

Professor Thomas Turner, of Birmingham, England, in an article in the Journal of the Society of Chemical Industry (May 29th, 1886, Vol. 5, No. 5), says: "Owing to the attention which has been devoted to the study of steel during the last thirty years, the chemistry of cast iron has not received the attention it really deserved, and consequently little has been done to elucidate the many problems which are as yet unsolved in this important branch of metallurgy."

In a paper read before the South Staffordshire Institute, Professor Turner says: "Unfortunatly it is the custom in many metallurgical books to speak of cast iron as though it were a perfectly definite and well known substance. In pig iron of course it is customary to speak of white, mottled and gray, and to divide the last variety into grades according to its characters, but when pig iron has been remelted, forming the material to which the name cast iron is most correctly applied, we have then little or no distinction made, whatever the characters of the product may be. But everyone familiar with foundry work is aware of the vast differences in the qualities possessed by different mixtures. They are hard or soft, strong or weak, brittle or tough, rough or smooth, fluid or thick, as the case may be, and none of these characters are of themselves either good or bad."

Founders, from long practice, generally know what mixtures will be most suited for the class of work they are on, but although they know that, ordinarily, such and such a mixture will produce the required result, they cannot tell *why* it is so, and consequently are many times led on the wrong track; a good illustration of this occurred not long ago, a large pipe foundry in the South ordered several hundred tons No. 1 mill pig iron from a well known fur nace, the first hundred tons worked well and gave good satisfaction, in the second lot it was noticed that the pig had a rough and somewhat pitted face, though the grain, color and strength were fully up to a good No. 1 mill. The first pour from this iron was a *total loss*, the shrinkage drawing the heads off from all the pipes and spoiling nearly every other casting. The founder had been so well pleased with the previous lot of iron that he would not believe that the trouble lay there, so he discharged some men for carelessness (?) and tried again with precisely the same results; next cast he omitted the pitted iron from the charge and obtained good castings, again he used one pig of pitted iron in a charge and then two and then four. During this time his other iron was from a Birmingham, Ala., furnace and contained very high silicon, this ran short and in place of it he used an iron with low silicon and his shrinkage trouble came back with the first cast. By that time the trouble was becoming monotonous and he complained to the furnace company, they took the affair in hand and examined into it, on analyses it was found that the No. 1 mill with pitted face contained 1.02 *silicon*, the No. 2 foundry (?) used, from the Birmingham furnace, contained 4.32 *silicon*, and first class pipe, made from good iron, contained 2.27 silicon while the bad pipe contained only 1.67 silicon, the matter was, therefore, easily arranged, the furnace company giving some "Bright" iron to make up the necessary silicon for standard pipe, and giving also the proportion to mix in the cupola, in this way the matter was settled pleasantly for both parties.

Now had the founder known the composition and physical properties of the iron he would have saved several days' work and worry besides the money lost on the useless castings. Undoubtedly any founder could give instances where he might have avoided difficulties by knowing more of the chemical and physical character of the pig iron used.

It is well known that pig iron containing a high percentage of silicon acts as a "softener," but the reasons for this action of silicon are not so familiar to all. Scrap, with mottled and white iron, would, if melted in a cupola, give white and worthless castings, but by adding a certain proportion of silicon to this mixture we can get strong, gray and fluid castings to any degree of softness or hardness we may wish for.

Both Turner and Keep found that by melting various proportions of silicon with a hard iron they forced the carbon from the combination and obtained different grades, from close to very open grain. Silicon lowers the saturation point for carbon in iron and tends to throw it from the combined into the graphitic state, at least up to 6 or 7 per cent. silicon; beyond that it may possibly slightly increase the combined carbon, but this is still a matter of doubt. Silicon alloys with iron in all proportions at least to thirty per cent. Some have stated that it occurs occasionally in the graphitoidal state, but this is yet to be satisfactorily proved. It increases the fluidity, and possibly the fusibility, of iron, thus lessening the formation of blow-holes.

Manganese raises the point of saturation, that is, permits higher total carbon. Ferro-manganese often contains 5.5 per cent. and occasionally 7 per cent. of carbon nearly all in combination. Up to a certain limit the addition of manganese to pig iron seems to improve the grain and darken the color, *always increasing, however, the tendency to chill.* It alloys with iron in all proportions, but is easily removed by oxidation, even by silica, and partly in this way and partly in others it restrains the oxidation of iron, while sometimes permitting and sometimes restraining the oxidation of other elements. Manganese, according to a number of experimenters, can be partly volatilized at very high temperature. Its action in the foundry is much that of a purifier; it removes oxide of iron, sulphur, and silicon from the molten metal, thus helping to prevent blow-holes.

Caron found, from a series of experiments, that manganese energetically expelled sulphur, increased silicon (from the walls of the crucible) and had little effect on phosphorus. Howe says: "Under favorable conditions drop like masses separate from liquid cast iron and float on its surface;" in these Ledebur finds much more sulphur and manganese than in the mass.

	Carbon.	*Silicon.*	*Sulphur.*	*Manganese.*
Segregation, ...	3.318	1.869	0.223	5.188
Mother metal, ...	3.463	2.196	0.056	2.620

These are probably what some founders term sweat-beads.

In an experiment 2 per cent. manganese was added to an iron; after melting in a graphite crucible and pouring, analysis showed only 0.583 manganese in the casting or 29 15 per cent. of the amount originally added. The balance all fluxed away during fusion, with the silicon and sulphur contained in the base. One rather curious thing was noticed on breaking the test bars of iron to which manganese had been added. That was, the metal, in bending, seemed to give way internally with a sudden drop, but afterward sustained much more weight. This giving way was accompanied by a sound resembling the familiar "cry" of tin.

Sulphur, like silicon, seems to lower the saturation point for carbon in molten iron and thus to lower the total carbon, yet, like manganese, it prevents the formation of graphite. Iron greedily absorbs sulphur from any possible source, holding it up to 53.3 per cent. Howe says: "Sulphide of iron is probably not a uniform combination in cast iron, but is a sulphide, probably of indefinite composition, dissolved or suspended in particles usually so minute as to escape detection; it tends strongly to segregate or even liquate from cast iron; it is often very irregularly distributed. So Snelus, sifting the borings of cast iron found the finer and more graphitic portions unduly sulphurous." Silicon and sulphur appear to mutually exclude each other but not to an extent to be practically important. A basic slag in a cupola will remove sulphur from iron. Rollet found that a strongly basic slag in a cupola removed 85 to 90 per cent. of sulphur from moderately sulphurous cast iron and 90 to 95 per cent. of that of highly sulphurous iron.

We tried an experiment to see to what extent pure sulphur would be absorbed by molten gray cast iron saturated with carbon. Ten pounds of iron were taken and while in molten state five pounds sulphur was added, the lid quickly placed on the crucible and all put into the furnace. After reheating only five pounds of iron remained and that was as white as chalk. It contained but .75 per cent. sulphur and almost nothing else but pure iron. Very little carbon and that combined. On skimming the crucible, preparatory to pouring, a cloud of flakes of graphite filled the air. Sulphur, as is well known, increases the fusibility of iron, but makes it very sluggish and full of blow-holes.

Phosphorus unites readily with iron to about 26 per cent. Under strongly oxidizing conditions it is removed, as by oxides of iron and manganese. It seems to have comparatively little effect on strength under gently-applied load, but jerking or shock-like loads break it easily. It is said that phosphoric irons strongly incline to coarse crystalization, but there is no particular proof of this in any of the tests we have made. In pig and cast-iron phosphorus exists, most probably, as a phosphide. The formula Fe_3 P is suggested, and in cases of manganiferous irons Mn_2 P_3. Pourcel claims that high temperatures of the blast-furnace tends to increase the percentage of phosphorus in pig-iron. His gray iron, he says, contained more phosphorus than the white iron, but others do not find it so, and in a series of analyses made by us we found that the colder the iron the greater the increase of phosphorus and also of sulphur.

We present this in hopes of interesting those present in the method of testing iron as described and in the results which may be secured from it. We think that if this system could be used it would be of material assistance to every founder or furnaceman.

This paper gives but a general outline of what is being done in a scientific way, but in a short time we hope to offer a full record of results in readable form, trusting that what has been said has merited the attention of the members and that some may think it well to adopt our method.

[Mr. Fleming, who read the foregoing paper, exhibited a complete suite of test bars prepared by Mr. Keep, some of which were broken to show the grain and some left entire to indicate the form in which they were cast. One set showed the effect of the addition of silicon in increasing quantity to a base of white iron, the first addition being 0.5 per cent. In this bar there was a noticeable change from the base, a slight grain appeared, and as the percentage of silicon added became greater the grain grew dark and strong, the chill decreasing rapidly. A set of test bars showing the effect of increasing proportions of manganese added to a gray iron were also shown. In this the influence of manganese in increasing the chill was very marked, the smaller additions increasing chill slowly and finally turning the entire bar white. Specimens of iron containing 10 per cent. and 16 per cent. silicon, 13 per cent. phosphorus, 36 per cent. sulphur and 85 per cent. manganese were also exhibited. The ferro-silicon and ferro-manganese were commercial products, but the phosphide and sulphide of iron were made in the laboratory by Mr. Fleming. Among the oddities exhibited was a piece of thin stove plate showing the grain of the iron on the outside but with a chilled or white core running through the center and following all the sinuosities of the casting, the fracture at any point showing, within one-eighth inch of metal, three continuous and parallel well-defined layers, the white or chilled core being at every point enclosed by the gray metal of the casting surface.

Mr. Fleming expressed the hope that since Mr. Keep was the originator of this method of testing, his name be given to it and that in the near future iron would be graded, bought and sold as such strength, chill, &c., according to "Keep's test," and added that the method had been adopted by two of the largest works in the country, besides the Michigan Stove Company, of which Mr. Keep is the superintendent.—ED.]

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Narrative of the Eighth Annual Meeting.

Another successful meeting has been added to the list of pleasant annual gatherings of the United States Association of Charcoal Iron Workers, and those who participated in what will pass to our records as "The Nashville Meeting" will, we are sure, remember it with pleasure and gratification. The only point covered by the excursions connected with the Nashville meeting, which was embraced in our equally memorable Chattanooga meeting of 1882, was Birmingham, Alabama; but the Birmingham of 1887 is so different from the Birmingham of five years ago that a second visit was like viewing entirely new ground.

The faces of some of our older members were missed from the delegates in attendance, but there was a very satisfactory representation of members from twelve States and the interest evinced in the papers read, with the discussions thereon, was marked.

FIRST DAY.

Our Nashville friends had arranged that the business sessions be held in the ladies' ordinary of the Maxwell House, where most of the visiting members were registered, thus adding materially to the comfort of all, but, owing to a series of detentions which caused the trains arriving in Nashville from three directions to be several hours late, the initial session was not held, as announced, in the afternoon, and the formality of official welcome was dispensed with. The board of managers, however, utilized the time in giving audience to those who came with invitations for the Association to visit other places than those provided for in the published programme. It was found to be impossible to enlarge the route beyond that announced, and the kind invitations from Sheffield, Florence and Gadsden, Alabama, had to be declined with thanks. The evening session was opened by President Fuller, introducing Professor James M. Safford, of the Vanderbilt University, of Nashville, and State Geologist of Tennessee, who entertained the meeting by a delightfully presented resumé of the geology, topography and mineral resources of Tennessee, and answered many queries presented to him by members. It is hoped that the subject matter of Professor Safford's remarks may appear as a contribution to the JOURNAL.

Mr. H. S. Fleming, of Philadelphia, then read an exhaustive paper upon "Physical and Chemical Tests of Cast Iron as Applied in Practice," which commanded close attention from those assembled, and after adjournment his complete suite of samples and unique alloys were critically examined and discussed. The paper appears in this issue of the JOURNAL.

SECOND DAY.

The Association, augmented in number and accompanied by citizens of Nashville, boarded a special train of cars kindly supplied by the Louisville and Nashville Railroad Company, and were taken to various industries in and about Nashville.

The large foundries of the Philips and Buttorff Manufacturing Company were first visited, and the casting of stoves, hollow ware and mantels were examined, considerable interest being occasioned by the neat imitation of various woods in iron mantels. Proceeding to the new suburb of West Nashville, the incipient industries which are being erected to produce in large quantities shovels, rakes, hoes, wire cloth and wire goods, were inspected. But the interest of our members was centered in the new blast furnace plant of the Nashville Iron, Steel and Charcoal Company, rapidly approaching completion, and the plant of kilns connected with it, which will described in a future issue of the JOURNAL.

After luncheon in the open air, an address of welcome was made followed by a response and by numerous short speeches which took the form of a good-natured discussion of the protection to our industries as a National rather than a partisan principle. Both sides of the issue were discussed, until the locomotive whistle called all to the train for a visit to the famous *Belle Meade Stock Farm*, where General Jackson welcomed the party and escorted them to his park where three hundred deer run wild. A portion of the herd were driven before the party, and then the horses and cattle were visited until near dark when the train was taken to Nashville.

The evening session opened with a resumé of a paper by Prof. Henry E. Colton (who was prevented from being present), upon "New Fields for Charcoal Iron Manufacture," and the exhibition of iron and manganese ores from near Murphy, North Carolina. The secretary then read a letter from Mr. S. D. Mills, of St. Ignace, Michigan, upon "Absorption of Moisture by Charcoal," which provoked a most interesting discussion (the paper appears in this issue). This was followed by a recital, by Dr. H. M. Pierce, of "Experiments upon the Partial Substitution of Gaseous for Solid Fuel in the Blast Furnace," (the paper appears in this issue,) and, after the dicussion which ensued, Dr. D. Church spoke upon refrigeration of the acetic vapors from wood carbonization.

During this session the very cordial invitation for the Association to hold its next meeting at Anniston, Alabama, was read.

THIRD DAY.

On the Louisville & Nashville R. R.

A complimentary train awaited the visitors at the Union Depot, and soon they were scattered hrough the four sleeping cars provided by our Nashville friends, while in a day coach was a class of students from the Vanderbilt University (under the guidance of Professors Dudley and Magruder,) who accompanied the excursion and won the praise of all for their earnest investigation and gentlemanly deportment.

DECATUR, Ala., was the first stop made, and after a bountiful luncheon we were taken to the new blast furnace and charcoal kiln plant. Here a portion of the kiln plant was in operation, and ample time was given to inspect the method of elevating the wood from barges on the Tennessee river to the bluff, the filling of kilns and the introduction of gases in t e fire-places under the kilns, as well as the condensation of gases and the production of methylic alcohol. A detailed description of the plant is given in another part of the JOURNAL.

Carriages were then taken, the new industries, hotel and other features of the ambitious city exhibited, and at 8 o'clock all sat down to a banquet, which was followed by a number of short after-dinner talks and a reception, where the younger portion of the party enjoyed a dance.

While the bright future promised for Decatur may be discounted by the conservative element, none in the party could wish other than complete permanent success to a growing city which welcomed us so cordially while the embers of the most disastrous fire in its history were smouldering.

FOURTH DAY.

After midnight the special train was started southward, and when we awakened it was to accept at the hands of our Birmingham friends a complimentary breakfast, after which the two blast furnaces and coke plant of the Sloss Iron and Steel Company were visited, which, with the Alice and Oxmoor furnaces, were the only points of familiarity to those who had not visited the "Magic City" since the Chattanooga meeting of 1882.

Prior to inspecting the furnaces the special train was run up the Spur tracks to the quarries of the Birmingham Mining and Manufacturing Company, from whence the supply of flux for the blast furnaces at Birmingham is obtained. Returning to the city, a train of cars took the delegation out to the new furnace plant being erected by the Tennessee Coal, Iron and Railroad Company at Ensley City. This is the largest single enterprise in the Birmingham district and embraces four blast furnaces, each 20 feet diameter at bosh and 80 feet high. Each furnace is being equipped with four fire-brick stoves (Gordon-Whitwell), and the plant is supplied with twelve vertical blowing engines and sixty-four double-flue boilers. Delay en route prevented an inspection of the Pratt Coal Mines and only permitted of a distant view of the new plant of the Pioneer Iron Company, which is nearing completion.

Returning to Birmingham, the hospitality of its citizens was again expressed by a luncheon, and the special train carried the party to Bessemer. Here a plant of three blast furnaces is being erected by the DeBardeleban Coal and Iron Company. Each furnace is 17 feet diameter at bosh and 75 feet high. Five engines and five batteries of water-tube boilers will supply the power to operate the furnaces and seven fire-brick stoves will heat the blast. The little daylight remaining was utilized in viewing the new rolling mill being erected and in visiting the adjacent iron ore mines.

Assembling in the Montezuma Hotel, the final session of the meeting was held, when the Secretary's and Treasurer's reports as given in the JOURNAL were presented and action taken to place the Association's publication on a permanent basis.

At 8 o'clock the visitors were entertained at an elegant banquet, toasts being interposed between the courses, and at 11 P. M. farewells were exchanged and the train returned to Birmingham. This was a fitting finale for a very successful meeting, for although the special train carried many back to Nashville, others remained to become better acquainted with the development of the "Magic City" and surroundings or visit other points of interest, some of which will be referred to in the future.

Minutes of the Eighth Annual Meeting of the United States Association of Charcoal Iron Workers.

FIRST SESSION.

LADIES' ORDINARY, MAXWELL HOUSE,
NASHVILLE, TENN., *November* 15, 1887.

At eight o'clock the Association was called to order, President J. C. Fuller presiding. After introductory remarks from the chair the Secretary announced that the annual report would be presented at a subsequent session. Professor James M. Safford, State Geologist of Tennessee, was introduced and entertained the members by a discussion of the mineral and forest resources of Tennessee.

Mr. H. S. Fleming, of Philadelphia, presented for Mr. W. S. Keep, of Detroit, and himself, a paper upon "Physical and Chemical Tests of Pig Iron as Applied in Practice."

After a general discussion the meeting adjourned until eight P. M., Wednesday.

SECOND SESSION.

LADIES' ORDINARY, MAXWELL HOUSE,
NASHVILLE, TENN., *November* 16, 1887.

Meeting called to order at eight o'clock by President Fuller. The Secretary presented an abstract of a paper by Professor Henry E. Colton, on "New Fields for Charcoal Iron Manufacture."

Dr. H. M. Peirce, of Nashville, read a paper upon "The Substitution of Gaseous for Solid Fuel in the Blast Furnace."

The Secretary read letters from Mr. S. D. Mills, St. Ignace, Michigan, upon "The absorption of moisture by charcoal."

On motion of Mr. M. Lyman, a committee on nominations was appointed. The chair named Messrs. M. Lyman, New York; W. H. Rood, Michigan, and Joseph Vaulx, Tennessee, as the committee.

Mr. Dennis Church, by request, detailed some investigations made in refrigerating gases.

On motion of Mr. Walter Crafts, a committee on courtesies was authorized, and the President appointed as such committee Messrs. Walter Crafts, Ohio, H. M. Stoughton, Alabama, and M. Hoagland, New Jersey.

The Secretary read the following despatch, which, on motion, was referred to the new executive committee for action:

ANNISTON, ALA., *November* 16, 1887.

TO J. C. FULLER, *President:*

Anniston, Alabama, the centre of the most extensive charcoal iron interest, producing the largest quantity of the highest quality of charcoal iron in America, extends most cordially an invitation to the United States Association of Charcoal Iron Workers to appoint Anniston as the place of meeting of the next annual convention of your association.

R. P. HUGER, *Mayor*,
JOHN M. MCKLEROY,
SAMUEL NOBLE,
D. T. PARKER,
JOHN W. NOBLE,
HUGH L. STEVENSON,
WILLIAM NOBLE,
GEORGE NOBLE.

On motion adjourned, subject to the call of the President.

THIRD SESSION.

MONTEZUMA HOTEL,
BESSEMER, ALA., *November* 18, 1887.

The meeting was called to order at seven P. M., President Fuller in the chair. After explaining that the courtesies extended to the Association had prevented a meeting on the previous evening the Secretary read the following:

REPORT.

PHILADELPHIA, *November* 1, 1887.

To the Board of Managers of the United States Association of Charcoal Iron Workers:

GENTLEMEN:—

At the date of the last report, the roll of the Association included		286 members.
During the year the deaths, resignation and those dropped on account of default of dues for two years numbered	26	
The new members added were	12	
Showing a loss of five per cent.		14
And making our present membership		272 members.

Of these 258 are located in twenty-five States and one Territory, the remaining 14 being resident in eight foreign countries.

The geographical distribution of the members and associates, as given by States and countries, is exhibited in the following statement, which shows that at this date the support of the organization comes from all of the charcoal iron producing centers more nearly in the proportion of the number of industries than of their relative importance.

Pennsylvania,	64	Georgia,	3
Michigan,	29	Massachusetts,	3
Missouri,	26	Minnesota,	3
New York,	21	Texas,	2
Ohio,	20	Virginia,	3
Connecticut,	13	Washington Territory,	2
Alabama,	10	West Virginia,	1
Tennessee,	13	Colorado,	1
New Jersey,	11	Iowa,	1
Wisconsin,	10	Kentucky,	1
Illinois,	4	Maine,	2
Maryland,	6	Oregon,	1
Indiana,	4		
Delaware,	4	Total,	258

FOREIGN MEMBERS.

Canada,	4	France,	1
Sweden,	3	Hungary,	1
Austria,	2	Prussia,	1
Mexico,	1		
England,	1	Total,	14

To illustrate the present status of the Association in comparison with the record of previous years, the annexed statement is submitted:

	YEAR ENDING						
	Oct., 1881.	Oct., 1882.	Oct., 1883.	Oct., 1884.	Oct., 1885.	Oct., 1886.	Oct., 1887.
Honorary members,	8	8	10	11	9	9	9
Foreign members,	6	10	12	8	10	11	8
Members,	186	239	267	277	243	209	205
Associates,	....	16	51	68	55	57	50
Total,	200	273	340	364	317	286	272

The Association has not recovered from the depression referred to last year, and the Secretary cannot report as favorably as could be wished, the interest in the organization having apparently flagged until late in the year, the revival being largely due, it is believed, to the cordiality of the invitation of our Nashville friends. Present indications favor a considerable addition to the roll of members.*

The favorable responses to the action of the Association at its last annual meeting increasing temporarily the annual dues, were not sufficiently numerous to offer encouragement to the Secretary to make the improvements in the JOURNAL that were considered essential to its success as a publication, and the tardy remittances of others forced a longer interval than usual in the appearance of the JOURNAL.

Individual offers of financial aid from members were declined because it was considered unfair that the burden should fall on a few while all shared alike in any advantages arising from the organization. Words of commendation are very pleasant but they are not sufficient to maintain the publication of a periodical devoted to the manufacture of charcoal iron, and unless the JOURNAL can be more cordially sustained by the Association, its publication should be suspended or a wider field should be sought either for it or for the Association.

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* Late additions to the roll of members makes the total now about 320.—ED.

We must remember that the number of active charcoal blast furnaces is constantly decreasing although the production of pig iron with charcoal does not decline proportionately owing to the advancement made which insures a larger output per furnace, and the number of bloomaries or forges is rapidly becoming less. Therefore we cannot look for greatly enlarged membership, although all who would naturally be interested in the organization are not included on its roll.

Notwithstanding that the purposes of the organization are confined to those directly interested in the production of charcoal iron, our roll contains names of those prominent in other branches of iron metallurgy, and encourages the belief that additional interest could be secured by practically widening the field of the organization or at least of its publication without sacrificing any of its value to the charcoal iron industry.

The suggestion is therefore made that the executive committee be authorized to formulate a plan which will encourage the general support of all those interested in iron manufacture, and issue the JOURNAL as a periodical in this interest. It is not expected or desired that this publication be either a rival or in any way supplant the very creditable trade papers, or that the organization occupy the ground so well covered by technical societies. But after consultation with those competent to judge, it is believed that a business association devoted solely to the interest of iron production and manufacture and a publication giving attention to those features would be acceptable and successful.

During the year considerable interest in the subject of charcoal iron was attracted by a circular issued by the executive committee as follows:

PHILADELPHIA, *April* 15, 1887.

To the Members of the United States Association of Charcoal Iron Workers:

The recently increased demand for charcoal iron to be used in the manufacture of steel rails is believed by the officers of the Association to be of sufficient importance to call special attention to it by circular. A memorandum from one of our most active members contains the following statement:

"Some of the Western railroads have been experimenting with steel rails made of different kinds of iron, some entirely from coke iron, and others, in the same line of track, with a medium to large percentage of charcoal iron. They have found the rails with charcoal iron in them so much better, both in durability and safety, than those made of coke iron alone that the roads are specifying from 25 to 40 per cent. of charcoal iron to be used in steel rails in future."

Concerning the method of testing the durability of steels rails, we are informed by a member that "two miles of track of each of the different kinds of rails was laid on a part of the line bearing the heaviest traffic, and each marked and a record kept of the performance and results. The results were that the rails containing the charcoal iron were free from breakage and far more durable. The C., B. & Q. and the C. & N. W. railroads were mentioned as specifying 12 to 25 per cent. of charcoal iron to be used in rails for them."

The same activity seems to be spreading among the makers of car-wheel iron, and a decided improvement is reported by some whose specialty is the production of pig iron and blooms for boiler plates

Believing that with continued care in the selection of ores so as to produce charcoal iron of a superior quality, there will be a demand and remunerative prices for the product of all the charcoal blast furnaces of the country. The above is submitted for your information.

Respectfully,

J. C. FULLER,
President.
W. R. DAVENPORT,
Vice President.

JOS. D. POTTS,
GEO. G. LOBDELL,
C. E. COFFIN,
Executive Committee.

Attest—JOHN BIRKINBINE, *Secretary*.

The Secretary has information of the use of over 10,000 tons of charcoal iron in the manufacture of steel rails for one railroad company within six months of the present year. The specifications which have been seen required from 12 to 25 per cent. of charcoal iron to be used, the latter amount being most general.

That mineral fuel iron has to a great extent replaced charcoal iron for numerous purposes is well known, and we must expect this to continue; as the great bulk of the iron made is produced with mineral fuel, every effort will be made to introduce this product for purposes for which charcoal iron has been alone employed, but it is believed that the economies practiced by the manufacturers of charcoal iron or which are possible, will permit of this industry, maintaining its present position or even expanding in volume. It has been shown in the JOURNAL that notwithstanding the decrease in the number of charcoal blast furnaces, that the average yearly output taken by decades has materially advanced, the figures being:

	Total net tons.	*Yearly average—Net tons.*
Years 1857 to 1866 (inclusive), ...	2,608,724	260,872
Years 1867 to 1876 (inclusive), ...	4,230,894	423,089
Years 1877 to 1886 (inclusive), ...	4,733,962	473,396

The industry is therefore important enough to sustain an organization, but we must either curtail the work attempted by the Association or secure a larger income to carry on what has been desired.

Respectfully submitted.

JOHN BIRKINBINE,
Secretary.

FINANCIAL STATEMENT.

Receipts and Expenditures from November 1st, 1886. *to November 1st,* 1887.

	Dr.
To cash balance on hand November 1st, 1886, ...	$152 65
Receipts.	
To amount received for dues, ...	1,315 00
To amount received for advertisements, ...	22 75
To amount received for JOURNALS and contributions, .	183 00
	$1,673 40
Disbursements.	*Cr.*
By office expenses, clerical labor, postage, telegraphing, expressage and incidentals, ...	$350 82
Printing JOURNALS and postage bills E. K. Meyers and Lane S. Hart, ...	583 76
Stationery and incidental printing, ...	82 80
Engraving for JOURNALS, ...	86 00
Salary of Secretary for 1886, ...	467 78
	$1,571 16
Cash balance November 1st, 1887, ...	102 24
	$1,673 40

The liabilities of the Association to date are:

Bill of E. K. Meyers,	$142 54
And the Secretary's salary.	

At the end of last year there were bills outstanding against the Association, viz E. K. Meyers and Lane S. Hart amounting to $478 75; have been paid off during the year.

The apparent assets are:

Members' arrearage of dues, including special dues,	$1,135 00
Advertisements now due,	71 00
	$1,206 00

Some of this is uncollectible, but it is expected that enough will be received to counterbalance the liabilities and cover the expenses of the annual meeting.

JOHN BIRKINBINE, *Treasurer.*

On motion, the reports were accepted and action deferred until after the committees should report.

The Committee on Nominations, through Mr. Lyman, chairman, reported the following recommendations:

President—Samuel Noble, Anniston, Ala.

Vice Presidents—H. S. Pickands, Chicago, Ill.; Thomas H. Hays. Louisville, Ky.; W. H. Rood, Ishpeming, Mich.

In lieu of a full ticket of managers, the committee recommend that the Secretary be authorized to secure nominations from the various States in proportion to the representation on the roll of members, and that the following be chosen to form the Executive Committee and be included in the Board of Managers: George G. Lobdell. Wilmington, Del.; Joseph D. Potts, Philadelphia, Pa.; J. C. Fuller, Pine Grove Furnace, Pa.

The report was adopted and the Secretary instructed to cast the unanimous vote of the Association for the gentlemen named.

Mr. Crafts, for the committee on courtesies, reported that as many kindnesses had been shown the Association that an enumeration of the attentions received was impossible, he, therefore, moved that the Secretary issue a card of thanks to each of those who had favored us by courtesies. The motion was adopted.

The reports of the Secretary and Treasurer were then discussed, the sentiment being strongly in favor of continuing the publica tion of the JOURNAL under the direction of the Association or by members of the organization.

Mr. J. H. Hays, Kentucky moved that the Executive Committee be authorized to dispose of the JOURNAL of this Association to a company formed for the purpose of its publication under the present title and upon the following basis:

The company to have a capital of $1,000, of which 30 per cent. must be subscribed before any action is taken.

The company to continue the JOURNAL as the organ of the Association for at least two years, and furnish for one-half the annual dues a copy to each member.

Twenty per cent of all sales of back numbers of the JOURNAL to be covered into the treasury of the Association.

The resolution was adopted.

On motion, adjourned subject to the call of the Executive Committee.

Attest: JOHN BIRKINBINE,
Secretary.

Obituary.

Peter N. Brennan, treasurer of the Lobdell Car Wheel Company, died on December 3 at his residence in Wilmington, Delaware, after a short illness.

Mr. Brennan was about 70 years of age, and was born in England. While still a boy he was employed in a woolen mill near Wilmington, and it was here that he met with an accident which resulted in the loss of an arm. In 1857 Mr. Brennan entered the service of Bush & Lobdell, and on the dissolution of that partnership he became confidential clerk to Mr. George G. Lobdell, who continued the business. In 1867 the present firm of the Lobdell Car Wheel Company was incorporated and Mr. Brennan was made treasurer, which position he retained up to the time of his death.

Mr. Brennan has been a member of the United States Association of Charcoal Iron Workers for six years.

Absorption of Moisture by Charcoal.

By S. D. MILLS, *St. Ignace, Mich.*

[Read at the Eighth Annual Meeting of the United States Association of Charcoal Iron Workers, Nashville, Tennessee, November 16th, 1887.]

[Note.—During the second session of the Nashville Meeting, the Secretary read the following from a correspondence with Mr. S. D. Mills, who is in charge of the Retort Plant connected with the Martel Furnace, St. Ignace, Mich.—ED.]

* * * "I invite your attention to some observations on the subject of 'absorption of moisture by charcoal,' which were made during the winter, the weather being for the greater part of the time very cold, but broken by an occasional thaw. These thaws rendered it impossible to establish any regular rate of absorption over a length of time for different kinds of charcoal, but on the whole I found the absorption by brown charcoal was more rapid, and in some cases greater in ultimate quantity than that by fully carbonized or over-done charcoal, and the absorption by charcoal made from dozy wood was very rapid and large in ultimate quantity. Another point worthy of notice was that the increase in weight which took place during a moist day was not lost during the subsequent dry weather. in other words the charcoal did not dry again to any perceptible degree. It must be understood that none of the charcoal was exposed to weather but was kept in a closed shed were it could only be affected by the moisture in the air.

"Good well made beech charcoal absorbed of atmospheric moisture and gases 2.63 per cent. in 24 hours, and the ultimate increase of weight after 23 days was 7.89 per cent.

"Dozy beech charcoal absorbed in 48 hours 6.248 per cent. and in 5 days 9.372 per cent. This weight remained constant.

"Brown charcoal from beech gained in 48 hours 3.576 per cent., ultimate increase 8.75 per cent.

"Charcoal from green maple gained in 48 hours 2.802 per cent., ultimate increase 6.538 per cent.

"Charcoal from green beech gained in 48 hours 3.10 per cent., ultimate increase 7.14 per cent.

"In comparing charcoal produced from different kinds of wood I find that charcoal from green wood amounts to only 20 per cent.

of the weight of the wood, that from dry wood can be made to average 30 per cent. if slightly brown, and 28 per cent. if fully coaled: the green-wood charcoal also suffers from being badly checked, especially if the coaling is done rapidly. This probably is owing to the rapid generation of steam, the pores of the wood being full of sap, this steam finds its escape most readily along the lines of the medullary rays, and so splits the coaling wood into thin pieces. These pieces are usually rather dense in texture and, owing to this fact as well as to their slate-like form, they descend too rapidly through the furnace so that in some cases they find their way into the crucible and make the furnace work 'dirty.' I find green beech charcoal to be the worst in this respect.

"My observations were made entirely with retort charcoal, and they may therefore be matters of curiosity rather than of any real economic interest to many members of the Association. To obtain reliable data on this subject, I have learned, however, that the following rules must be observed, viz:

"As the absorption differs in different varieties of charcoal, it is necessary to make separate observations on each kind as, beech, maple, birch, etc.

"Each of these observations must be exactly simultaneous.

"A careful record should be kept of the hygrometric condition of the atmosphere during the entire time of the experiment which should last for not less than six weeks, the weights should be taken daily for the first six days and after that on every fourth day.

"To prevent loss the samples should be placed in tin boxes previously weighed (wooden or card-board will not answer as they will absorb moisture) and the samples must be weighed in the boxes.

"The experiments should be repeated at intervals of two months, to ascertain the effect of the different seasons of the year.

"The charcoal in every case must be weighed for the first time as soon as it is cold; it is hardly necessary to suggest that care must be taken not to take any charcoal which has been wet down at the time of drawing.

"The wood from which the charcoal is made must be all in equally good condition, if green it must be all equally green, if dry, care must be taken that none of it is dozy.

"A separate simultaneous series of experiments should be made in order to observe how much of the increase in weight is due to gases and how much to moisture, this is important as the gases may add to the calorific value of the charcoal, while moisture diminishes it.

"There are two other matters to be remembered in making observations of this kind, first, the rapidity with which the charcoal has been burnt appears to affect its absorbent powers, second, the presence of tarry or pitchy matter in the pores of the charcoal may destroy its power of absorption to a great degree.

"You may judge from this, that such an investigation is no trifling matter and requires much time, more in fact than I could at present give to it, besides the Martel Furnace kilns are 12 miles from the furnace, and we never get the kiln charcoal till it has been at least 24 hours drawn. Hence no effort at comparing kiln and retort charcoal was made.

"In connection with this subject I may mention that the retort charcoal does not seem to do quite the same duty in the furnace as the kiln charcoal, I used to think this was a prejudice on the part of the founder but have come to the conclusion that there is a reason for it. The retort made charcoal in almost every case where it has been used for furnace work, has been exposed to the air not longer than 15 or 20 minutes before going into the furnace, and it may be that its inferiority is due to the fact that it has not had the same chance to have its pores filled with gas as the kiln made charcoal, which is generally 24 hours, in some cases many days, exposed to the air before being used. You may see from the data given that the most rapid absorption took place during the first 24 hours, and further that this increase in weight was about the same for similar charcoal, no matter what the weather happened to be like at the time. This is, to my mind, pretty conclusive proof that the increase of weight during the first 24 hours is chiefly due to gases and not to moisture."

[Mr. Mills also made the following suggestions regarding the spectroscopic phenomena of iron smelting to which we give place. —ED.

* * *

"I think that by observing the spectrum not only of the gases from the 'bleeder,' but also that of the flame from the cinder notch and from the iron notch at the termination of the run of cinder or iron, as well as the varied spectra of the corruscations and flames seen so often on certain grades of iron in the casting beds, much important information might be gained respecting the causes of many unexpected variations in the nature of our pig iron. Why is iron one time tight, and at another time open-grained? Why is it that an alteration in the aperture of the tuyeres suffices (without any change of charge or of quantity of air used) to totally change the nature of the chill? Mr. Secretary we are only on the shores of the sea of knowledge and hoping that some of the more fortunate ones may at least succeed in wetting their feet in its waters at the coming convention, I wish you with all heartiness 'God speed.'"

* * * * *

The president referred to the value of such data as was presented by Mr. Mills and expressed a desire that the members present discuss the correspondence as a paper presented.

DISCUSSION.

Dr. H. M. **PIERCE**, Tennessee. "Charcoal when taken directly from the kiln and put into the furnace does not behave as well, nor appear to do as good work, as charcoal that had been seasoned a little or had time to receive moisture. His interpretation of this fact was, that when the charcoal comes from the oven, it contains carbonic acid gas which would behave badly in generating heat, hence it might be that charcoal that had stood 24 hours would do better work than charcoal taken right from the furnace."

Professor J. M. **SAFFORD**, Tennessee, said, "It is a well-known fact that charcoal absorbs a great deal of gas in its pores. Take a piece of charcoal which has been exposed to the air for several days and from it an immense volume of gas may be released much larger in volume than the charcoal itself. It is impossible to tell what the effect of these gases would be without experiment."

The Secretary read an extract from the JOURNAL, Vol. II, p. 221, and Vol. III, p. 230, upon the absorption power of charcoal.

Prof. **SAFFORD** remarked, that this referred to charcoal that had been exposed to different gases, but we had not these different gases in the charcoal as used, for instance, laughing gas.

Mr. C. **KIRCHHOFF**, Jr., New York, asked if it were not possible that a parallel existed in the case of charcoal and coke. The retort coal was said to be inferior as a furnace fuel as kiln coal. In using coke as a blast furnace fuel, that which was produced in kilns in which the by-products were saved was not considered equal in quality to that made in the ordinary oven. He asked if Dr. Pierce had found that the withdrawal of the gases from the charcoal in any way deteriorated the quality of the charcoal.

Dr. PIERCE said that he believed the saving of the gases in the carbonization of wood did not make any difference in the quality of the charcoal. He described the firing of the charcoal kiln and stated that ordinarily 33% of the wood in a kiln is used in generating heat to reduce the balance to charcoal, every piece of wood being taxed to supply heat to reduce the whole to charcoal. He did not see that any difference was made by using the by-products.

Mr. BIRKINBINE expressed the belief that charcoal in a closed kiln or retort could be damaged by making the by-products the primary object or vice-versa. He cited a case where the Millerton furnace using charcoal made in a battery of retorts in central New York and also charcoal made in horizontal retorts in northern Pennsylvania. and said materially better results were obtained from the charcoal made in the retorts than from kilns although often inefficiently managed. But none of the charcoal was used fresh, it was all transported by railroad.

The President alluded to an experience in which a man who was hauling charcoal by wagon for his furnace threw a large quantity of water upon the coal, which was absorbed to the extent of 40 or 50 bushels in every load.

A letter was handed to the chair and read by the Secretary from the "Eureka Iron Works," Mich., as follows:

DETROIT, MICH., *November* 14, 1887.

I have pleasure in complying with Professor Mathieu's request for a certificate as to his charcoal.

We have used the charcoal made by him at Luther in his special retorts, and prefer it to any other charcoal we get. We think it does better service in the furnace.

We haye had a contract with him for his entire supply, and have just renewed it for a further period.

THE EUREKA IRON AND STEEL WORKS,
By W. K. MUIR, *President.*

Mr. C. J. KIRCHHOFF, Jr., New York, stated that the veteran metallurgist, P. V. Tunner, has lately called the attention of the

Austrian iron trade to efforts being made in Sweden to improve their blast furnace work by a preliminary drying of the charcoal used. From his review, published in No. 42 (October 15th) issue of the Oesterreichische Zeitschrift für Berg-und Hütten-Wesen, the following points may be alluded to: It naturally would seem as though the evaporation of water in charcoal might be left to be done in the simplest and cheapest manner in the blast furnace itself, but it must not be forgotten that the moisture in charcoal causes some cooling of the charge, and that it therefore retards the reduction and the expulsion of the carbonic acid. The result is that there will be fluctuations and disturbances in the process, affecting necessarily the quality of the pig iron produced. This, Mr. Tunner argues, in many cases entails loss far more serious than the average cost of expelling the moisture from the charcoal before it is charged. Another circumstance may be thought to be influential in making the drying of charcoal before charging worthless or even injurious. Experience in a number of places has shown that fresh charcoal which is, of course, dry, will carry less burden in a furnace than the same quantity of charcoal which has been stored under cover for a number of months. Mr. Tunner states that more than sixty years ago he had experimentally shown that fresh charcoal, kept under cover, increased in weight several per cent. in the first few days, this increase growing smaller and smaller until after about fourteen days it became imperceptible. In all, this increase in weight ranged between six and eight per cent., the dense, good coal increasing more than older, porous fuel. This is a circumstance that appears to prove to many that this increase of weight is not only due to absorption of moisture, but must be chiefly ascribed to the absorption of gases, the oxygen of the air being absorbed in relatively greater quantity than the nitrogen. But this apparent drawback is removed by the fact that the preliminary drying of the charcoal is not carried to an extreme, but is continued only until evidence of evaporation ceases. This point may be easily noted, since the expulsion of the last parts of water absorbed and of gases requires a long time and a high temperature. Mr. Tunner states that the drying of charcoal has been in use in Sweden for more than six years with more or less success; and he dwells upon the results brought out at a meeting on the 8th of June, 1886, of the Sweden iron companies.

Two different methods have been in use in Sweden for drying charcoal, the first being that introduced by M. Lindberg, and in use for a number of years at Dalkarshyttan. The second method is that of G. Uhr, first used at Bångbro and then at Mokärnshyttan, Horndal and Sandviken. In both methods the drying is done with the aid of heated air, but the manner in which this is carried out is radically different. At Dalkarshyttan the charcoal to be dried is placed in wire baskets, set on a car which is carried into a long brick tunnel, in which a current of hot air circulates. The trouble in this arrangement is that it is impossible to avoid a good deal of dead space between the charcoal and the sides of the tunnel, so that the hot air cannot easily be forced to travel through the charcoal itself. This involves a long continued drying, a large number of baskets, a long tunnel, a suction fan at one end and a blower at the other, so that the whole apparatus becomes very costly and cumberous. The latter arrangement consists in placing the charcoal into sheet-iron baskets having a perforated bottom, so that the air entering through the latter directly flows through the charge, this arrangement being used at Horndal, while at Bångbro and Mokärnshyttan the hot air enters from above and passes out through the perforated bottom. In some apparatus the heating of the air is done by utilizing the heat of the pig iron produced and the cinder, but this method has been shown to be unsatisfactory.

G. Uhr has, therefore, used the waste gases from the furnace by suspending above the open top a funnel protected by wire cloth, through which he draws the waste gases, and propels them into the vessels in which the charcoal is to be dried. In order to keep the temperature uniform and have it below that at which charcoal ignites, he aims at a heat of 80° celsius (176° F.), the charcoal igniting at 100° celsius (212° F.). It is found, however, that a heat of 40° to 50° celsius (104° to 122° F.) is sufficient, and in order to keep it at those figures, a varying quantity of air is allowed to be drawn in with the waste gases by the suction fan, the gases leaving the drying apparatus at a temperature of only 15° to 30° (59° to 86° F.). At Horndal a drying apparatus has been shown to effect an expulsion of moisture drying from 8.42 to 31.4 per cent. in the case of wet small coal. The average, however, at Horndal, where special pains is taken to keep the coal dry, is only 3 to 4 per cent of loss in weight, so that in that case, which unfortunately is rather exceptional, artificial drying does not really possess great advantages. It takes on an average 3.47 hours to effect the drying, the process being conducted according to the apparent moisture in the coal. In the case of furnaces with closed tops the simple arrangement of taking off the waste gas cannot be used, but Mr. Tunner believes that there can be no difficulty in taking from the chimney of the hot blast a sufficient quantity of waste gases with the aid of a suction fan to effect the same purpose. This would not disturb the utilization of the waste gas of the blast furnace for other purposes; on the contrary, their quality would be improved because they carry less steam.

In answer to a question from Gen. Warner, the Secretary said that much of the moisture in charcoal was driven off by the heat of the ascending gases in the blast furnace, at the same time the Swedish experiments must be based upon some resultant saving, or they would not go to the expense of drying the charcoal before putting in the blast furnace.

Gen. Willard Warner, Alabama, stated that he had been in the habit of roasting brown hematite iron ores to get rid of the water, of which they carry about 12½ per cent. This roasting has been generally practiced throughout the South, but it is now becoming customary to work ore raw, depending upon the heat of the ascending gases in the furnace to get rid of the moisture without loss of fuel before they reach the point of fusion. Tennessee furnaces adopted this plan and Mr. J. C. Warner, when asked by the speaker how much more coal it required to work raw ore, said that it did not take any more. If it were possible to get rid of 12 per cent. moisture in the ore at the top of the furnace without loss of fuel, could we not get rid of the 2 or 3 per cent of moisture in the charcoal in the same way?

As to oven or kiln charcoal, he had had 14 years' experience in its use as compared with pit or meiler charcoal and his experience was, that the best possible charcoal that could be obtained in the pit was better than the best charcoal he had ever seen made in the kiln or oven, but the average of the oven charcoal was better than the pit charcoal. Charcoal made under dirt was sure to be more or less wet and to have considerable sand, dirt and stones mixed with it, which sifted down through the charcoal; oven charcoal on the other hand was perfectly dry and clean. The whole question, however, depended on the collier, the wood must be in good condition, not green or dozy, and the heavier, solider and better the wood, the better the resultant charcoal. He did not see any difficulty about the use of the gases if the collier handled the kilns well. Some of the densest charcoal he had ever seen was made under the Pierce process.

Mr. VAULX, of Tennessee, then made a few remarks about the washing of ores. He said that washed ores required less coal than roasted ores. His neighbor's experience has been that he had been paying for 200 or 250 pounds of dirt with every ton of ore when not washed and he could make a ton of iron from 20 per cent. less ore than when he roasted it All his ore was now washed except the large lumps In the furnace he was alluding to before washing the ore, 136 bushels of charcoal were used to the ton of pig iron, since washed ore was used 105 bushels of charcoal was the average.

Prof. SAFFORD inquired whether it would take less fuel if the washed ore was also roasted.

Mr. STOUGHTON, of Shelby Iron Works, also said he was roasting his ore as well as washing it and the furnaces had shown a much higher precentage of yield, as high as 65 per cent. from brown hematites.

[The discussion of moisture in ores being incidental to the subject of Mr. Mills' letters, was considered as appropriate by the Chair.—ED.]

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"THE enormous development of our internal industry has now made it necessary to seek foreign markets for our surplus productions. But in this exigency our manufacturers and merchants cannot afford to depend on foreign bottoms. We want American bottoms, from the keel up, with American bunting flying from the masthead, and proudly representing the great Western Republic, with its 60,000,000 sovereign people and a commerce capable of world-wide expansion."—*Iron Age.*

Partial Substitution of Gaseous Fuel for Solid Fuel in the Blast Furnace.

By Dr. H. M. PIERCE, *Nashville, Tenn.*

[Read at the Nashville meeting of the United States Association of Charcoal Iron Workers Association, November 16, 1887.]

Our Secretary and other members of this Association have requested me to furnish a statement of the results of experiments in supplementing fixed with gaseous fuel for smelting ores in the manufacture of pig iron. This I do with reluctance, growing out of the fact that the experiments are incomplete and the results attained not of sufficiently pronounced character to enable me to furnish this Association with a paper satisfactory to myself.

I however affirm that the work already done in this direction is satisfactory to myself *as the first step* in a new field. With mind prejudiced and preoccupied by the form of a furnace commonly used for making pig iron, experiments naturally turned towards a blast furnace similar to those in general use; and I therefore constructed a small blast furnace, the dimensions of which are given in the accompanying statement, with tuyeres, hot-air blast, and in all other respects similar to the common form, with the exception that it had but two air tuyeres and one gas tuyere. The air tuyeres occupied the same position in the experimental furnace as in the common charcoal blast furnace, while the gas tuyeres entered 15 inches above the air tuyeres. A Sturtevant fan for introducing my gaseous fuel and a Baker blower for introducing air into the furnace were employed. An improvised hot blast of six-inch wrought iron tubes for the air and a similar hot blast for the gaseous fuel were used. These were heated by gas from the top of the furnace as is customary. The average temperature of the air and gas as they entered the furnace was from 450° to 500°. When completed, the experimental furnace was placed in charge of Mr. Geo. W. Cunningham, who had had large experience in running the charcoal blast furnace at Elk Rapid, Mich., and the La Grange and Warner furnaces in Tennessee, requesting that he should start the furnace in the ordinary way, using air alone until he had ascertained its capacity and behavior.

Mr. Cunningham accordingly ran it about three weeks without regard to gaseous fuel, with an average production of about two and one-half tons of pig iron per day. The gas was then turned in, and, as will be learned from the statement accompanying this paper, resulted in bringing the product of the furnace up to an average of six tons per day. The experiment was brought to a close, first, because we had used up all the ore on hand, and, secondly, because I had obtained the data expected from this my first test.

Those associated with me at Goodrich, where this experiment was made, believed the work done in supplementing fixed with gaseous fuel sufficiently promising to warrant the erection of a larger furnace that the test might be made on a larger scale. A 25-ton furnace was accordingly built at Goodrich by Dr. D. Church similar in all respects to the ordinary charcoal blast furnace. We employed a Weimer blowing engine for supplying the air to the furnace. Believing that the wood gases, with which I proposed to supplement the charcoal, were too moist and contained too much acid to enable me to use the Weimer or common cylinder air pump, I did what in my inexperience was judged to be best and selected a Baker blower, especially made for the purpose. This furnace was placed in the hands of Mr. Charles Woolner, who had been operating the Fruitfort charcoal furnace, Michigan, and he ran the furnace with charcoal alone as fuel for two or three weeks, securing an average output of iron of from 22 to 23 tons a day. Gas was then applied to the furnace through two of the four tuyeres on the same horizontal plane with the air tuyeres. The hot-blast ovens for air and gas were fitted up with 10-inch wrought-iron pipes, laid horizontally, with supports of railroad iron to prevent them from bending in times of great heat. On administering the gases to the furnace it was at once discovered that *they were moist and deposited moisture around the tuyeres; and, furthermore, that the Baker blower could not deliver against the Weimer engine.* After having made a fair trial, the gases were removed and the furnace was continued in operation with air and charcoal alone. Attention was then directed towards relieving the gases from all moisture, which I fully succeeded in doing by passing them through a series of scrubbers located between the condensers and the Baker blower. On administering the gases a second time it was discovered to our satisfaction that no moisture was developed about the tuyeres, so one obstacle to successful application of gaseous fuel to the large furnace was thus happily removed. We discovered the second obstacle could not be so readily overcome. The Baker blower could not deliver the gaseous fuel against the positive air blast of the Weimer engine, and I there rested with the belief that should we go to the expense of obtaining an ordinary cylinder blast engine as favorable and perhaps more conclusive results would be obtained than in the experiment with the small furnace. Circumstances, however, interposed that prevented further work in this direction.

This second step taken with the large furnace was satisfactory to myself and strengthened the belief, which I still firmly entertain, that with proper conditions, and after patient experiment, pig iron could be produced, even in the ordinary furnace, with 50 bushels of charcoal supplemented by the gaseous fuel arising from the carbonization of wood.

Since finishing the last test I have not been in circumstances favorable to continue this most interesting and, I believe, important work. As soon as other duties admit I shall resume work in this direction, with unwavering faith in the ultimate success.

I herewith submit the details of my first experiment:

"Comparative performance or experimental furnace at Goodrich, Tennessee, in smelting ores, by the use of charcoal alone, and by the use of charcoal and gas combined:

FURNACE: Crucible, 20 inches diameter, by 24 inches deep; greatest diameter of furnace (bosh), 39 inches; diameter at top, 30 inches; height of furnace, 16½ feet; no bell and hopper.

FEBRUARY, 1885.

From February 17, 6 A. M., to February 20, 6 A. M, three days, the furnace working on charcoal alone as fuel, there was charged into furnace, of charcoal, 19,200 pounds; there was charged into furnace, of ore, 19,930 pounds; being in proportion of 100 pounds charcoal, to 103.8 ore.

From February 20, 6 A. M., to February 23, 12 M., three and one-fourth days, the furnace working on charcoal and wood gases combined, there was charged into furnace, of charcoal, 32,000 pounds; there was charged into furnace, of ore, 45,800 pounds: being in proportion of 100 pounds charcoal to 145 ore.

From February 23, 12 M., to February 26, 12 M, three days, the furnace working on charcoal and wood gases, there was charged into furnace, of charcoal, 28,300 pounds; there was charged into furnace, of ore, 46,765 pounds, being in proportion of 100 pounds of charcoal, to 161.69 ore.

RECAPITULATION.

	Charcoal.			*Ore.*	
Furnace on coal alone, three days, average charge, ...	100	pounds	to	103.8	pounds.
Furnace on coal and gas, three and one-fourth days, average charge, ...	100	"	"	145	"
Furnace on coal and gas, three days, average charge, ...	100	"	"	161.69	"
Furnace on charcoal, total ore charged per day, ...				6,640	"
Furnace on charcoal and gas combined, total ore charged, ...				13,784	"
Furnace on charcoal and gas, to verify the performance of the first three and one-fourth days on coal and gas, during a three day's run, ore charged per day, .				15,583	"

At the conclusion of the test, the furnace was very hot, and, in the judgment of those conducting the trial of using wood gases to supplement fixed fuel in the smelting of ores, it would have carried a still greater burden of ore to the uniform proportion of charcoal used per charge. Test ended for want of ore.

The average grade of pig iron made, was Nos. 2, 3 and 4. An incidental result of the test was the probability that with the use of gas, the grade of iron could be run uniform or varied at pleasure, each successive casting, by varying the quantity of gas used. The apparent reason was that the temperature of the furnace could be instantly changed in all its parts, by varying the quantity of gas. Whereas, in using fixed fuel alone, the variation of the temperature is necessarily slow, and must begin with the charging at the top of the stack.

GEORGE W. CUNNINGHAM,
Foundryman in charge."

The following letter from Mr. Cunningham also gives additional data concerning the experiment:

GOODRICH, TENNESSEE, *February* 23, 1885.

"After experimenting with Dr. Pierce's small furnace with charcoal a few days, we put on the gas as a mixture with charcoal to estimate its value in smelting iron. The charge was at that time 100 pounds of coal, 110 pounds of ore, and the furnace making Nos. 2 and 3 iron. With the gas mixture, we have increased slowly each day without interruption or accidents. The charge is now 100 pounds of coal to 160 ore. Furnace still on grades of Nos. 2 and 3, the same as when we introduced the gas.

We are still obliged to increase ore. The furnace when filled with charcoal contained only 75 bushels, while running since we have used the gas, the furnace changes its charge in four hours. With a larger furnace the ore would have a longer time to prepare. We are obliged to use extra blast to consume the gas.

We have open-top, without bell and hopper. You will see that is another disadvantage. I would certainly call this a great success. The test has been very interesting, and has taught me some things entirely new."

In conclusion, I would state, that, after having completed the first experiment with a view of supplementing fixed fuel with gaseous in a small furnace, I shipped to the Pittsburgh testing laboratory a few tons of iron produced by the use of gaseous and fixed fuel ores. I did not inform those conducting this laboratory of the quality of iron ore used, or how it was produced, but simply requested that they give the results of exhaustive analyses of the iron, and tests as to its tensile strength, etc.

The analyses and tests made by this firm, are submitted, together with the report of Mr. William F. Zimmerman upon the results of his analysis of this iron. I also submit analyses made by three different and well-known chemists, of samples of iron produced at the Warner Furnace, Hickman county, Tenn., from the same quality of ores and limestone used in the small experimental furnace, with a view of comparing the iron produced by fixed fuel and fixed fuel supplemented with gaseous.

Analyses of pig iron marked H. M. Peirce and numbered 1623: Pittsburgh Testing Laboratory.

Silicon,	0.973
Sulphur,	trace
Phosphorus,	0.465
Manganese,	0.306
Total carbon,	2.691
Iron (by difference),	95.565

TESTS.

Number of test.	*Area of test bar in sq. ins.*	*Tensile strength in pounds per square inch.*
1623,	0.798	22.860
1651,	1.	28.370
1652,	0.7854	22.410
1653,	0.7823	18.940
1654,	0.9993	22.280
1655,	1.008	22.080
1656,	1.003	24.070
1657,	1.001	23.980

NOTES.

Number 1623 was taken from a pig.
Number 1651 was remelted and broken as cast.
Number 1652 was remelted and turned down from a 2-inch square casting.
Number 1653—Ditto, showed impurities in fracture.
Number 1654, cut from corner of 6-inch square green sand casting.
Number 1655—Ditto, from 6-inch square dry sand casting.
Number 1656—Ditto, from 4-inch square dry sand casting.
Number 1657—Ditto, from 4-inch square green sand casting.

ANALYSES OF "WARNER" PIG-IRON.

Grade.	*No. 1 foundry.*	*No. 2 foundry.*	*No. 3.*
Graphitic carbon,	3.69	3.94	3.50
Combined carbon,	0.17	0.205	0.38
Silicon,	1.5	0.921	0.77
Phosphorus,	0.19	0.362	0.325
Sulphur,	—	—	0.003
Manganese,	—	0.749	—
Analyst,	Chauvenet,	Britton,	Potter.

REPORT OF W. F. ZIMMERMAN.

The analysis of the iron tested for you is similar to that of Hecla iron No. 1, with the exception of the total carbon and phosphorus. As the carbon is a matter of running the furnace, it need not be considered. The phosphorus, however, is quite an important item, making the iron more or less cold short and affects the strength of the iron. A mixture of one-half your iron and one-half Salisbury would undoubtedly make a very good iron for car wheels. However, you may use ores with one per cent. less of phosphorus and make an iron equally good as Hecla. In working your iron it appeared quite dirty. This, however, the writer believes can be remedied in the furnace. The strength of the iron is about the same as good Hecla or Salisbury iron of the same grade. The iron took about a ⅜-inch chill, and the writer believes that it would make a good car wheel iron. For comparison, the writer gives the analyses of several standard brands of car-wheel iron:

Name.	*Salisbury.* *Per cent.*	*Hecla.* *Per cent.*	*H. M. Pierce.* *Per cent.*
Silicon,	1.39	.93	.973
Sulphur,	.04	.074	trace.
Phosphorus,	.28	.355	.463
Manganese,	.457	.421	.306
Total carbon,	3.93	4.59	2.691
Chill,	⅛″ to ¼″	⅜″ to ½″	⅜″

I do not see that I can do more in the present state of affairs, as we have not made a sufficient number of analyses to make a very strong or definite report. We can say that with care in manufacturing this iron should be made as good a foundry iron as is needed for large castings, or a good car-wheel iron by changing the running of the furnace."

MUIRKIRK FURNACE, at Muirkirk, Md., made the following record for the eleven weeks ending on November 1: Tons of iron (2,240 pounds) made, 1,137; average make of iron per week, 103.36; best week's work, tons, 110; pounds of ore used, 5,346,780: pounds of oyster shells, 996,622; pounds of charcoal, 2,466,500; bushels of 20 pounds of charcoal, 123,325; pounds of charcoal to ton of iron, 2,170; bushels of charcoal to ton of iron, 108.5; pounds of ore per ton of iron, 4,702; pounds of shells per ton of iron, 876; total ore and shells per ton of iron, 5,579; burden per pound of fuel, 2.51; average heat of blast, 700°; furnace, 29′ 6″ high, boshes, 100″; blown with four tuyeres, nozzles, 3″; two horizontal blowing cylinders; capacity of blowing cylinders per revolution, 192 cubic feet; average revolution of cylinders, 8. Furnace blown out for want of ore.

A Direct Method of Producing Malleable Iron and Steel.

By G. HUSGAFVEL.

[Translated from Jern-kontorets Annaler, 1887.]

[NOTE—For the following description of experiments in blast furnaces with movable hearths, and with double iron shells, we are indebted to Mr. F. Lynwood Garrison of Philadelphia, who has lately visited the plant in operation at the Dobriansky Iron Works in the Ural district of Russia.

We had examined with interest the illustrations which appeared in connection with Mr. Husgafvel's paper in the Jern-kontoret Annaler, and which are reproduced in the JOURNAL; but the novelty of the design, and the results obtained were not fully appreciated until Mr. Garrison permitted the use of a translation of the text. The paper possesses such merit that we have given it but little revision, feeling confident that our readers would appreciate the details of construction and operation as given in the original. We have been shown samples of the blooms made, which were brought to this country by Mr. Garrison, and we are indebted to him for the memoranda at the close of the translation.—ED.]

TRANSLATION.

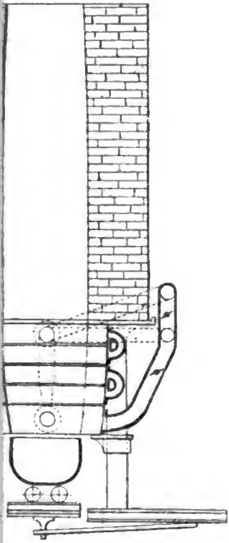
THE DEVELOPMENT OF THE CONSTUCTION OF THE FURNACE.

It is well known that malleable iron and steel is produced chiefly from pig iron by being refined in various ways, and to avoid indirect and costly methods, has long been, and still is the desire of metallurgists in different countries. Most of the methods for producing iron directly from ores known up to the present time have failed, so that many of them exist only on paper, and none have practically gained well-known or important use. The failure of these methods has naturally caused a strong prejudice amongst metallurgists against all direct methods in general, and authorities have raised their voices against trials with them. If on the one hand these circumstances have increased the difficulties for in-

D

1882

orsaskoski



ventors to have their ideas accepted or put in practice, they should on the other hand stimulate the inventor to test the value of each method impartially. The above mentioned reasons, as well as a want of sufficient capital, caused the method herein described for the direct production of malleable iron from the ores (the development of which has consumed twelve years of work), to be unknown to the public until the present time, and even now it is not developed to such perfection that it cannot be improved in technical and economical respects. The results obtained with the furnace in Finland, and recently in the iron works of Count Stroganoff, at Dobriausky, in the Ural (Russia), nevertheless show that the principles in the construction of the furnace are correct, and that there is no doubt or uncertainty in judging of and regulating the smelting operations. The principle which lies at the bottom of the process is the so-called "Astman" blast or "Hark" process, well-known to and used by our ancestors, but the manner in which my process is operated differs so much from the older ones that it may be considered as essentially different.

In the Russian *Mining Journal* two papers about my methods have appeared: First, 1885, No. 9, "New Material for the Open Hearth Process;" second, 1886, No. 11, "The Production of Open Hearth Iron and Steel from Phosphoric Lake and Bog Ores in Finland." In order to outline a true description of the method, and also to correct some mistakes occurring in these papers, a short description of my different furnaces and results obtained with them is presented, which may indicate the direction in which further improvements are possible. In order to obtain a clear idea and an easy comparison illustrations of the furnaces and results are given:

Illustration "A" shows the type of the old "Hark" furnace, such as was in use up to 1875, at Porsaskoski, in Finland; to obtain better results with larger furnaces of this type proved a failure, as for each bloom produced the furnace had to be blown out, and for each operation in a larger furnace an increased quantity of charcoal was necessarily burned without corresponding advantage. The first improvement was in 1875, when a movable hearth was constructed, which in the beginning was made of three-eighth inch plate iron and the interior lined with clay, quartz and lime. In consequence of frequent repairs to this lining the hearth was replaced with one of cast iron without any lining. Since a continuous operation of the furnace was obtained with the movable hearths, there appeared to be a possibility of obtaining better results than before with furnaces of greater dimensions.

After trials with several different furnace constructions, and when two tuyeres had been put in, the furnace had, up to 1880, the shape shown by "B." The productive capacity of the furnace and the economical results had been improved, but the product was not homogeneous; the cause of this was that the reduced iron stuck to the brick walls in the lower part of the furnace, in consequence of which "scaffolds" were formed, and when these dropped down an irregular operation was the result. The temperature in the lower part of the furnace became so high that pig iron was formed.

In order to avoid the above mentioned difficulties and to decrease the temperature of the blast, it was determined to make the walls thinner, only 4½ inches, and provide the furnace with a hollow cast iron ring just above the hearth, in which tuyeres cooled with water and movable in all directions were inserted. This altered furnace, shown in "C," was erected in Pankakoski, Finland, in 1880. The hollow cast iron ring was cooled with water in the beginning, but it soon became evident that such strong cooling was not necessary, and did not answer the desired purpose, the air being enough to keep the outside sufficiently cool. The blast for the operation of the furnace was heated to 110 or 112 Celsius (230° to 234° Fah.), with the waste heat from the hearths in which the blooms were refined. As far as I know, up to this time a warm blast had not been used in a "Hark" furnace. The results which were obtained with this furnace were superior to those previously secured, the iron seldom stuck to the walls, and the blooms became more homogeneous, but irregularities in the operation of the furnace were nevertheless present.

In order to make it possible to regulate the changes of temperature, which were caused by non-homogeneous materials, or by other reasons, and at the same time to cool down the lower portion of the furnace, it occurred to me to try hollow furnace walls, and to allow the cold blast before it reaches the tuyeres to pass through these hollow walls, which must thereby be cooled down, while at the same time heating the blast.

The first furnace in which this idea was put in practice was erected at the Kulebaki Iron Works in Russia in 1882. The erection of the furnace was begun without necessary drawings, and the hollow sections were made of cast iron segments in such a manner that the blast passed from one compartment to the other, not as it should have been done by spiral tubes, but simply by holes in the bottom of the segments. This manner of building the furnace caused leakages between the segments, the blast also passed into the furnace above the tuyeres and the consequence of this was that the ore melted too soon. The furnace was nevertheless put in operation, and in the beginning good results were obtained. The blooms were directly hammered, and part of them rolled to muck bars, but after some days' operation the results became unsatisfactory, and after the furnace was blown out, it was observed that the leakages between the segments had increased in size, and the walls of the furnace was cracked in places. Other errors had also been made in building this furnace, and as at the same time General G. von Struwes, the owner died, the intention of rebuilding the furnace was given up.

During the same year I erected another furnace at my Pankakoski iron works shown in "D," the lower part of which was made of hollow cast iron walls, so arranged that each segment formed a separate closed apartment connected with its neighbor by a knee tube. The blast entered at the highest and was taken out at the lowest compartment, conveyed to the tuyeres which, as in the furnace at Pankakoski, were inserted into the lowest hollow cast iron segment. In the outer cast iron wall were arranged observation holes covered with glass so as to note, if possible, how much the inner wall was heated. After the furnace had been blown out and started again many times, it was interesting to see that its cast iron walls which had no lining were not appreciably attacked.

An important advantage in this furnace was, that the iron never stuck to its walls, and, although the temperature in the lower part of the furnace was comparatively low, (the inner walls being scarcely dark red) a good welding heat was nevertheless predominant in the hearth. The operation of the furnace was approximately regular, but the resulting blooms were uneven at the bottom and full of slag.

The tuyeres were too high above the bottom of the hearth, and the blast did not have sufficient effect at the bottom. This furnace had but a short existence, as in the beginning of 1883 it was blown out, in consequence of a scarcity of water, and by carelessness cold blast was forced through the still hot furnace, the consequence being that two of the cast iron segments cracked.

The results obtained lead to the following conclusions: First. By the passage of the blast through the walls of the furnace, they are kept so cool that there is no danger of their being burned. or oxidized, even if made of iron plate without lining. Second. This method of heating the blast affords a means of regulating the operation of the furnace. To increase the temperature of the blast, and when desired to alter it, it further occurred to me to provide the furnace with double walls of plate, so arranged that the cold blast can be admitted between them at different levels. This arrangement for the admission of the blast between the walls of the furnace also enables alterations to be made in the furnace itself, and thus regulate the operation of the process.

In the year 1884 this principle was applied, and a furnace with double walls of soft plate iron was erected at the Wartsila Iron Works. This furnace is described in the Russian *Mining Journal* of 1886, No. 11; it will, however. be sufficient to call attention to illustration "E."* Comparing the results which have been obtained at the above mentioned furnaces, erected in Finland, it is found that the productive capacity had increased in nearly the same ratio as the increase in the size of the furnace, and at the same time a saving of fuel has been obtained, although in a decreasing ratio for each increase in dimension.

These different phases of development, which these furnaces have undergone from the original "Hark" furnace "A," with its immovable hearth is shown in the furnaces "B," "C" and "D," differing not only in size, but also in having a movable hearth.

The furnace "D" having in its lower part hollow walls of cast iron, also exhibits a transition stage to the furnace "E," which has hollow walls to its entire height, or rather double plate walls with a circulation of blast between them, and tuyeres in the walls of the movable hearth. In all the preceding examples the tuyeres were placed in the lowest part of the furnace itself above the movable hearth.

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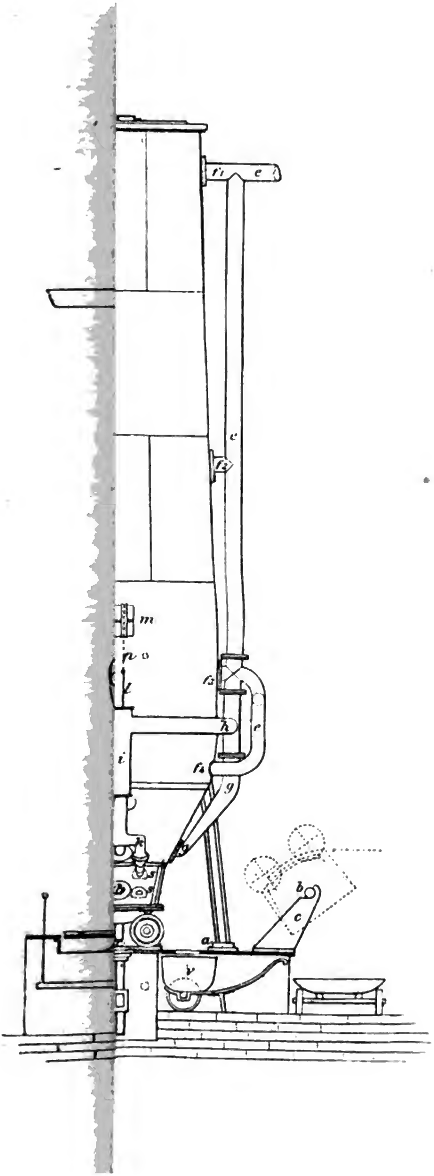
* The letters refer to the inserted plate.—ED.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The great saving in fuel which the furnace "B" exhibited in comparison with "A" is easily explained by the effect of the movable hearth, by the aid of which, a continual operation first became possible. The expenditure of fuel in the Wartsila furnace "E" appears to have been slightly lower than in the Pankakoski furnace "C," but taking into consideration that the ores at the latter works are richer than at Wartsila, the difference in the results are more pronounced.

The "Hark" blooms in the Wartsila furnace were, besides more homogeneous, and contained less slag than those made in any of the preceding furnaces. If we now compare the results obtained in the oldest furnace "A," with the Wartsila furnace "E," it will be observed that the latter, whose volume is about eight times greater than that of the former, also produces eight times more iron, and the expenditures of charcoal which, in the furnace "A" was 280 units of weight to 100 units of weight of blooms, is in the furnace of "E" for the same quantity of blooms, is only 105 units of weight, and that furthermore, the expenditure of ore for 100 units of weight of "Hark" iron has gone down from 536 to 313 units of weight.

The favorable results obtained with the Wartsila furnace in all respects, when compared to those of any of the preceding furnaces, is considered to be caused by the circulation of the blast between the walls of the furnace in connection with the forcing of the blast through several tuyeres into the hearth itself.

The former prevents the too early "sintring" of the ore and the charge from sticking to the walls of the furnace. The iron is not oxidized when the blast is forced into the hearth itself, which at each change of the hearth is filled with charcoal, and the several tuyeres with which they are provided tend to make the product more uniform. This is made clearer in the description of the process itself.

Even if the furnaces above mentioned had not existed at these places, others have been operated elsewhere under similar circumstances, the fuel and ore being the same; the charcoal being made from coniferous trees in meilers.

In the presence of two Russian mining engineers, in the autumn of 1885, the charcoal in the Wartsila furnace was replaced with the same weight of coke, and no especial difference in the operation of the furnace, or the results obtained were observed, but the trial was so brief that no data could be obtained as a basis for any conclusions.

By "Hark" or "hark-iron," is understood a bloom just as it comes from the furnace, without being mechanically treated. In consequence of the large amount of phosphorus in the ores, the blooms are non homogeneous and cold-short, and would have to be further treated in hearths or by the Siemens-Martin process. We will return to this question further on.

It has been shown that it is possible to reheat and directly roll bark blooms, but the constantly increasing requirements as to purity and homogeneity in the iron, cannot possibly be met with in the product made with impure Finnish ores. For this reason my furnace has principally been used to produce material for the manufacture of ingot metal.

Let us now turn to the furnace built and started by Count Stroganoff at Dobriansky, in Russia, the first furnace designed for hard refractory ores. In the contract for the erection of two furnaces at this place, the administration of Count Stroganoff required that, if possible, they should be built so that the blooms obtained could be directly hammered, reduced and rolled without remelting. In consequence of this provision it was desirable that the furnaces should be so constructed as to avoid the faults at the Wartsila furnace. These deficiencies were, that when the movable hearth was taken from the furnace and lowered to be drawn out, it caused a corresponding lowering of the material in the furnace. When the hearth is removed more material falls down on the side of the new hearth, which is opposite the drawing-off side, that is when the hearths are all drawn off on the same side, this causes a slope in the material in the furnace, and the stock does not arrive uniformily prepared at the hearth.

Again, the hearth at the Wartsila furnace is deficient, in that great difficulty is at times experienced in separating the blooms from it, and the joints often have to be loosened to get the bloom out. Again, the tuyere walls of the hearth burn out comparatively fast, and the unreduced iron sticks to the thin brick lining in the lower portion of the stack, which sometimes occasions irregularities in the working of the furnace. At Dobriansky these difficulties are completely eliminated.

The intention was to make the Dobriansky furnaces 35 feet high, of which 9 feet was gas "take-off," but in order to complete the building as soon as possible and put the furnace in operation, it was determined that for the present the gas "take-off" would be dispensed with, the results given below being obtained with a height of 26 feet calculated from the movable hearth to the throat. The diameter of the belly is 5 feet, and of the throat 4 feet. As shown in "F" this furnace will be seen to consist of an immovable part, the shaft, and a movable part, the hearth. The former consists chiefly of two round and concentric shells of iron plate, tightly fastened together at their upper and lower ends, the inner shell having a less diameter, so that there is a space between them of 7 inches, which is divided into spiral shaped channels by means of a thin plate fastened to the inner shell. Each shell from the bosh downwards is made of one-half inch plate, above the bosh the inner shell is three-eighth of an inch, and the outer one-fourth of an inch, and the upper section being three-sixteenth of an inch thick. The shells are riveted together at the bottom upon an interposed malleable iron ring.

At the lowest continuation of the shaft is a cast iron ring, which at its upper edge is concentric with, but somewhat less than the inner shell, and extending downward, gradually takes a quadratic shape with rounded edges. Outside of this cast iron ring a conical shell of iron plate is supported upon its (the cast iron ring) flanges, and in this part a hollow space is also formed which is connected with the space between the plate walls of the shaft by means of two broad flat tubes situated on opposite sides of the furnace. This cast iron ring is also securely fastened to the outer wall, or shell, of the shaft by means of four plates. By this arrangement it is easy to repair the lower portion of the furnace, the only part exposed to a high temperature. The inner plate wall is lined with bricks made of "chamotte," a mixture of fire-clay and crushed fire-brick, one and a half to two inches thick, for a height of five feet above the upper edge of the cast iron ring. The upper part, as well as the cast iron ring and the hearth, are without any lining.

The immovable part of the furnace is supported by four pillars, each consisting of two rails united together and inserted into two strong cast iron sockets, the uppermost being fastened to the outer mantle of the furnace, and the lower to a cast iron bed plate. This plate rests on a foundation made of ordinary bricks two and one-half feet high, in which two channels are left crossing each other at right angles.

The movable hearth consists of six parts of cast iron, an immovable bottom, to which two iron axles with their wheels are fastened, two tuyere walls each with four tuyere holes *s*, two slags walls each with four tapping holes *t*, and finally a movable bottom *u*.

The walls of the movable hearth are fastened together and to the bottom with bolts and nuts. The upper part of the tuyere walls is cast with a tube coil of wrought iron surrounding the upper tuyere holes for the passage of cooling water. In the tuyere walls of the hearth are two trunnions of wrought iron *b*, upon which the hearth can be revolved over two cast arms *c*, fastened to the edges of the bottom plate. The hearth stands upon a platform provided with rails, which can be raised or lowered by means of the lever *d*.

Two such hearths are required for the operation of the furnace, but a third is necessary in case one of the others should become damaged.

The blast necessary for the operation of the furnace is passed through the tube *e*, from which it can be admitted into the space between the plate walls or shells of the furnace at the four different levels of the tubes f_1, f_2, f_3 and f_4. The blast is then conducted through the tube *g* to the tube *h*, and thus distributed to the two sides of the furnace. By the tube *i* it goes down to the tuyere stocks *k*, two on each side. These tubes and stocks can be moved vertically by means of the central rods *l* and the chains *n* with their counter balances *o* passing over the wheels *m*. The tuyeres are also movable in all directions by means of the ball and socket joints *p*.

For the erection of such a furnace with three hearths there is required:

Cast iron, ...	**361.17**	**Centner.=[33,841.6 pounds.]**
Plate and other malleable iron,	**169.00**	**Centner.=[15,835.3 pounds.]**
Total, ...	**530.17**	**Centner.=[49,676.9 pounds.]**

Each furnace requires a space of 1,120 square feet, 40 feet in the direction in which the hearths are moved and 28 feet in width.

At the end of June, 1886, the furnace started and some trials were made with ore and slag in mixed quantities. After two days the work was stopped to correct defects in the movable bottom of the hearth, which was destroyed partly because the slag flowed between the bottoms; the lower tuyeres were also too low, being only five inches from the bottom, thus exposing it to too great a heat.

In the beginning of August the furnace worked regularly, but the numerous holidays in Russia caused many interruptions, and checked the operation of the furnace. After a run of 44 days the furnace was again "blown out," but started within three days afterward. On investigation after blowing out, it was found that the shaft, bosh and upper hearth were in perfect condition, and that the brick lining was unaltered. The cast iron ring in the lower part of the furnace was in place, covered with a thin layer of oxide, which fell off during the investigation.

On November 30, 1886, the furnace was again blown out, but even now after an operation of 119 days needed no repairs. During the comparatively short time the furnace had been in operation several materials had been tried, magnetic, spathic and brown iron ores, hearth, refined and welding slags, crop-ends and roll scales partially mixed with ores and partially alone. The greatest interest was taken in the magnetic iron ores from Maloblagodatj, which were used for a considerable time. Up to November 30, this furnace had produced 4,000 centner (187.4 net tons) of blooms, of which nearly all were taken directly from the movable hearth to the hammer in order to be shingled and divided into commercial blooms, in which state they have been weighed.

As changes in the ores and slags were frequently made, there was also many variations in the production. When only slags were used the out-put in 24 hours was limited to 23–27 centner (2,155.1 to 2,529.9 pounds), but when magnetic iron ores took their place the production went up to 73 centner (6,840 pounds). The charcoal was produced either in meilers or ovens from the ordinary Siberian fir, which yields such a porous charcoal that it can easily be powdered in the hearth, and the weight of a korob of such coal is 15 pood equal to 44.22 pounds per Swedish tunnor* (——— pounds per bushel.)

The charcoal was taken from the coal house, the percentage of water not being determined, 381 tunnor (1,394.46 bushels) of newly made birch charcoal, weighing 259 centner (24,268.3 pounds) was also tried.

The charcoal was assorted according to size into two kinds, and was charged by weight in such a manner that the coarse being charged first, and then the fine to fill up the spaces, so the ore should not pass through too rapidly.

The ores and slag charged were crushed by hand and passed through one-fourth and one-half inch mesh sieves; the roll scale was used without any preparation. Later on both ores and slags were charged in a finely crushed state. All the slags and one part of the magnetic ore was used unroasted, but the greater part of the latter was, in the absence of kilns, roasted in the puddling and reheating furnaces, or in the cupola. The special object of roasting is that the oxidization of the ore could not be obtained in this furnace. By two analyses the unroasted ore was found to contain 20.7 per cent. of protoxide of iron, and after being roasted 19.4 per cent. The chemical composition of the magnetic iron ores, according to five analyses were as follows:

ANALYSES OF RUSSIAN MAGNETIC IRON ORES.

	I.	II.	III.	IV.	V.
Iron,	.....	.....	.....	.....	57.92
Fe_2O_3,	65.01	63.01	69.1	52.34	.....
FeO,	20.95	21.06	18.98	24.89	.....
MnO,	2.79	3.64	2.84	2.25	2.64
MgO,	2.62	3.77	2.25	1.2	3.67
CaO,	1.10	1.58	1.12	1.2	2.83
Al_2O_3,	0.42	3.00	0.56	2.7	3.06
$Si O_2$,	5.41	4.43	5.2	11.9	7.09
Volatile Matter,	0.42	.....	0.02	3.0	.....
Sulphur,	.....	0.20	0.032	.....	.....
Phosphorus.	0.15	0.12	0.06	.....	0.06
	98.87	100.63	100.342	99.48	.....

An average shows the ore to contain about 58 per cent. of iron.

The results obtained with the furnace are arranged in Table I. which shows an extract from the books of the works

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* One Russian korob=13.06 tunnor; one Russian pood=0.385 centner.

THE OPERATION OF THE PROCESS AND THE QUALITY OF THE PRODUCT.

The starting and management of the furnaces:

When the furnace is to be started the joints between the walls and the loose bottom of the hearth are tightened with charcoal powder. After this hearth has been somewhat warmed, the inside of it is coated with a thin mixture of clay and lime or dolomite, which protects the walls from oxidation, and the iron from sticking to them. The hearth is now filled with charcoal and pushed beneath the furnace, when in the proper position the upper edges of the hearth are coated with ordinary clay, and then raised up against the furnace by means of levers, and the slag holes plugged with clay. The furnace is now filled with alternate layers of charcoal and ore mixed with fluxes. As an example of the rate of charging one case will be mentioned, where spathic ore yielding from 45 to 47 per cent. of iron was used:

Number of charge.	*Charcoal.*	*Iron scrap.*	*Ore charge.*
1, ...	180 skalp.*	20 skalp.	40 skalp.
2, ...	120 "	20 "	50 "
3, ...	100 "	20 "	60 "
4, ...	100 "	20 "	70 "
5, ...	100 "	20 "	80 "
6, ...	100 "	20 "	90 "
7, ...	100 "	20 "	100 "

With the same amount of charcoal an increase of 5 skalp of ore is given on each charge until the furnace is full. The addition of the scrap is made in order to make use of the great expenditure of charcoal in the beginning, and is continued until 4.6 centner (431.02 pounds) of scrap has been charged.

Until the furnace is half full, the charges should be laid regularly, and be levelled into horizontal layers, so distributed as to have more ore and flux towards the walls than in the middle of the furnace,

The filling of the furnace at Dobriansky takes 32 charges of 100 Russian pounds, or 30.8 centners of charcoal; 46.2 centners of ore and flux and 4 centners scrap. Assuming that one Swedish tunnor of this charcoal weighs 44.22 skalpund, the volume of the furnace would be $\frac{30.8\times100}{44.22}$ 69.6 tunnor, or 434 cubic feet (Swedish)=405.38 English cubic feet. The ore and scrap do not take any especial room, but fill the spaces between the charcoal. Theoretically the volume of the furnace would be about 400 cubic feet. After the furnace is filled and the blast is ready to be put on, some glowing pieces of coal are introduced into the hearth through the lowest tuyere openings, and the blast gently put on at about two lines quicksilver. As soon as the charcoal is well ignited, the blast is shut off for about half an hour so that the time for the preparatory heating of the charges may not be too short. When it becomes possible to ignite the gases at the throat of the furnace (which takes place within an hour after the first igniting), the blast is gradually increased according to the circumstances. In the beginning, or as long as the ore charges are small, the blast is let in at the lowest part of the space between the walls and the shell so that the cast iron ring may not become too hot. Afterwards, when more ore has come down, the inlet of the blast is moved higher up, the tuyeres placed in the lower tuyere holes and inclined towards the bottom of the hearth, but as the bloom increases the inclination is lessened, so that the blast always sweeps over the bloom. When it has grown up nearly to the lower tuyere holes. the tuyeres are removed to the upper holes and the lower ones plugged with clay.

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* One skalpen=100 Swedish pounds=93.7 English pounds.

At the most suitable time the slag is tapped off through the slag holes. Care must always be taken that sufficient slag remains to protect the iron from oxidation by the blast, and also that the gases do not blow out through the slag holes. The slag flows down through an opening in the bed plate into a small wagon beneath. Before the bloom has reached a medium size another hearth, to replace the first one, is filled with charcoal and ignited. When the bloom is to be taken out the movable platform is lowered and the old hearth replaced with a fresh one. When the new hearth has come exactly beneath the furnace, the platform is raised and the joint between the hearth and furnace tightened with clay. After this, full blast is turned on again. The full hearth is drawn towards one of the pair of dumps, turned round on its axis and should the bloom not fall out by its own weight upon the platform wagon standing below, several strong blows are struck upon the bottom knob of the hearth with the effect of separating the bloom. To prevent the loose bottom from falling out together with the bloom, it is provided with a key in the knob. Thus the process goes on with an interruption of from five to ten minutes for the removal of blooms.

As the furnace becomes hotter the ore charges are gradually increased until the maxium is reached, which can be accomplished on the second day after the starting. For each 100 skalpund of charcoal, 240 skalpund of spathic ore could be charged with advantage, or from 150 to 160 skalpund of magnetic ore from Maloblagodatj. In the beginning, however, we went too far in increasing the charges of spathic ore up to 290 skalpund, and the magnetic ore up to 200 skalpund per 100 skalpund charcoal. The consequence of this was that the percentage of iron became low, so the magnetic ore gave only about 40 per cent.; this explains the low medium results which the books of the works shows up to October 1, in comparison with the results obtained after that date.

To the above mentioned large ore charges is also probably due the fact that some of the blooms suffered from red or yellow shortness during the hammering or rolling test to which they were subjected at a yellow heat, the details of which will hereafter be given.

THE MANUFACTURE OF MERCHANT IRON FROM BLOOMS.

In the first trial to weld and hammer "Hark" iron blooms, 779.8 centners were taken just as they came from the hammer, without selection, after the furnace was in working order. Amongst these were 79.4 centners made of roll scale. The welding or reheating was done in an ordinary gas reheating furnace, in which the blooms were subjected to from one to four heats, and were hammered out 6 inches square, with sound and clean surfaces. Of the above mentioned amount (779.8 centners) 694.4 centners of "muck iron" 6 inches square were obtained, making a loss of 85.4 centners or 10.95 per cent. The greater part of the above mentioned "muck bar" was broken cold and assorted according to the appearance of the fracture. Partly of these and partly of unbroken muck bar, 600.9 centners, were taken besides 112.25 centners of unwelded blooms, or a total of 713.15 centners, which were delivered at the rolling mill. The welded and unwelded iron was rolled separately, in order to see the respective results. From the 600.9 centners of welded bloom, 524.42 centners of 7 inch by one-fourth inch rough plate were obtained on rolling, which was capable of being reduced into fine plate of which only 58.26

centners were rejected. This was faggoted and welded into bars giving, with 42.48 centners of trimmings, 556.9 centners of iron. The loss was thus 44 centners or 7.32 per cent. In rolling the 112 5 centners of unwelded iron, 62.37 centners of rough and 26.98 centners of bad plate were obtained, this, together with 8.47 centners of trimmings, giving a total of 97.7 centners, with a loss of 14.5 centners, or 12.91 per cent.

All the unwelded iron was subjected to two heats in rolling: 3,263 pieces of rough plate yielded 392 centner or 2,637 pieces of first, 314 second and 312 third-class plates. All the above is what the Russians call red plate (rodplate). The first and second classes are further treated into black plate; the third class is used for various purposes. The uncut plate weighed 393.4 centner, thus there was no loss; after cutting, 352 centner of plate and 41.4 centner of trimmings were produced. At the further treatment to black plate 2,029 pieces, weighing 224.33 centner produced 1.946 plates ready for market, weighing 177.37; 83 bad plates of 6.66 centner and 31.87 centner of trimmings, making a loss of 8.43 centner during the treatment. In regard to these figures it should be observed that the blooms at the first hammering appeared to be somewhat "dry," that is free from slag, and on rolling appeared like iron refined in a Lancashire hearth, although somewhat softer. and the rough plate required less rolling. These plates also had fewer spots and flaws than plates made of refined or puddled iron. As is shown by the above figures, these spots did not have any effect on the final product, and could be compared with those made of other iron. When a bending test was made with the plate and its trimmings, it appeared softer than plate made of puddled iron.

It appears from the books of the Dobriansky Iron Works that differences in the appearance of the shingled blooms was not accompanied by any important differences in either the loss or the quality of the plate. Furthermore, when the blooms from the Husgafvel furnace were directly hammered and rolled, it might be expected some faults would be detected. No doubt such faults can be avoided by greater skill and experience in the workmen. The chief objection to the quality of the product is the above mentioned shortness at a yellow heat, which some of the blooms exhibited in rolling.

For roof plate and other finished products which are not subjected to further heating or treatment, the above mentioned shortness is of no special importance. The capacity and ability of the Husgafvel furnace to treat successfully hard refractory ores, even as unreducible as magnetites has been here fully demonstrated. And even if we have not sufficient data to draw definite results regarding the direct rolling of the blooms; considering the relatively small quantities that were tried, there seems to be a good prospect that the direct production of "ready" (merchant) iron, pure and clean, from pure and rich ores may become practicable.

THE PROCESS.

Considering the process going on in the Husgafvel furnace, it has been suggested that the chief reason of the product being malleable iron or steel, must be attributed to the fact that the ore charges are higher per unit of charcoal than in the case of a blast furnace. The ore is charged with the flux, lime or dolomite, so that the earthy matter, as well as a part of the unreduced iron may combine with it and form an easily melted and quick slag as possible. The blast is conducted through the hollow walls of the furnace, the consequence of which is, that the stack is kept comparatively cool, and at the same time a high temperature is produced in the hearth and lower part of the furnace. The blast is heated during its passage through the walls, cooling down the stack and retarding the reduction of the ore by the charcoal, so that the reducing action is concentrated in the lower part of the furnace, not much above the tuyeres, in consequence of which the reduced iron has not time to take in sufficient carbon to form pig iron. Thus the carbonization generally stops before a more or less hard steel is formed, which at the tuyeres is in a more or less doughy condition and sinks down through the thin fluid slag, beneath which it coagulates itself together and forms a bloom. In passing the tuyeres during the "sinking" the greater or less part of the combined carbon is oxidized, according to the direction given to the blast in the hearth. One part of the carbon thus removed, it may be further oxidized by the action of the blast upon the surface of the bloom. It should here be observed that the iron in the bloom is partly compact and partly solid, like blooms which are produced by the refining of pig iron in a hearth, and not like iron sponge, as might be supposed. Besides, by the inclination of the tuyeres the carbonization of the reduced iron can be regulated, both by the ore charged, the quantity of air supplied, and the height at which the blast is introduced through the iron mantle which surrounds the furnace. It is also obvious that the process can be conducted so that, instead of wrought iron or steel, pig iron can be produced. The reason of this is, that in this furnace more ore can be charged on the charcoal than in a blast furnace, and the iron is not so completely reduced; which circumstances compensate in many cases for the loss of iron which takes place in the conversion of pig iron into malleable iron.

In former times blast furnaces were built with very thick walls, but of late years they are made much thinner, and at the present time there are celebrated metallurgists who consider that the thin walls prevent too high a temperature, and give more advantageous results to a blast furnace than if it had thick walls. In the Husgafvel furnace peculiar appliances for lowering the temperature are used, and by their means the heat is kept away from those parts of the furnace where a high temperature is not only unnecessary, but even detrimental; in other words, this superfluous heat is taken up by the blast and introduced into the hearth where it is needed. The above mentioned lowering of the temperature causes no injurious effect on the proper working of the furnace, provided the inner shell is surrounded with a bad conductor of heat. Except for the heating of the blast, the regulation of the smelting process and the working of the furnace, the object of the introduction of the blast between the walls of the furnace is to cool them down so as to prevent the iron from sticking to them and forming a scaffold, it also checks the reduction of the ore by solid carbon.

THE PRODUCTION OF DIFFERENT DEGREES OF CARBONIZED IRON.

The differences in the operation of the furnace to produce malleable iron or steel, are chiefly that the ore charges in the first case are made larger than in the latter. When hard or very carbonized iron or steel is desired, the temperature in the lower part of the furnace must be higher, and the inclination of the blast into the hearth less than when soft iron is produced. The operation of the process can be judged by the light from the tuyere holes and a throat flame; but the safest guide is the quality of the slag and bloom, which can be investigated by means of a small iron rod introduced through the tuyere holes. In a good and normal operation the light from the tuyere holes should be bright and clear, and the throat flame lively and bright. When soft iron is formed in the hearth the surface of the bloom should feel hard, even slippery when touched with a cold iron rod; but when the rod has become warm and the iron particles from the bloom stick to its end, it is a sign that the heat in the hearth is sufficiently high. The slag flows well with a light color. If the surface of the bloom is hard, uneven, or indicates holes, then the furnace has been driven too fast, or too much ore has been charged. The slag then becomes very quickly fluid, having a yellowish to red color, which indicates a great loss of iron. With an increasing degree of carbonization the slags become thicker, tougher and less fluid, at the same time the surface of the bloom becomes soft according to the degree of carbonization.

THE REGULATION OF THE OPERATION OF THE FURNACE.

The possibility of obtaining a homogeneous product depends, of course upon the regularity of the operation, this again is mainly due to the materials being of the same size and quality; to uniform and regular charging at stated intervals, and to a uniform temperature and quantity of the blast, the degree of heat must have a great influence as can easily be understood.

When we remember that the degree of carbonization of the iron depends not only upon how complete the reduction, increased by the temperature has become, but also upon that temperature, at which carbonization takes place; and as it is in practice impossible to have the materials and temperature constant and regular, we realize that the operation of the furnace in consequence of this and other reasons, cannot always be depended upon. It is therefore necessary to regulate the process, if possible, and for that purpose the Husgafvel furnace is provided with an arrangement to admit the blast between the walls. In order to see how it is operated we may, for instance, suppose that soft iron is desired, but that the heat in the furnace by some reason is increased and the melting operation has consequently become so disarranged that pig iron has begun to form, causing a very great diversion from a normal operation. In order to bring the furnace back to its proper condition, the blast should be admitted lower down between the walls of the furnace, but of course when this is done the temperature of the blast is changed. When a great quantity of blast passes through the walls of the furnace it must be cooled down in its lower part and the temperature of the blast decreased, as its route is thereby shortened. The blast which now has greater pressure and a lower temperature, carries more oxygen into the furnace during a unit of time, the consequence being that the driving is increased and the temperature of the charges in higher parts of the furnace is decreased, and the time of reduction and carbonization of the iron is shortened. But all these circumstances have the same tendency, viz: the production of a less carbonized iron. For this purpose a stronger blast, especially when much inclined, is a greater benefit, as it refines the over-carbonized iron. If, on the other hand an increase of the temperature in the lower part of the furnace should be desired, it can easily be obtained by decreasing the pressure of the blast and admitting it higher up in the walls. In order to have a margin in both directions, it is necessary during the normal operation of the furnace not to introduce the blast through the highest vent, but somewhat lower down in the walls, and with a thermometer placed in the hot blast tube, not only the temperature of the blast, but also the variations of temperature in the furnace will be indicated, and with care these variations can be avoided. Irregular quality of materials, irregular charging or the wrong composition of these charges, besides too fast or too slow driving, and other reasons may also cause the furnace to depart from its normal operation; but such great and costly irregularities as sometimes occur in blast furnaces cannot arise in a Husgafvel furnace, because the hearth can be taken away and replaced with another at will. Notwithstanding that a small furnace is more sensitive to variations than a large one, this furnace, by means of the above described inlet of the blast between the walls, has an excellent means of both indicating and preventing a change in the temperature of the blast, upon which a regular operation of the furnace depends. When the blast is heated by the walls of the furnace in which it is used, it is obvious that when other circumstances are unaltered, as for instance, the pressure and volume of the blast, an increase or decrease of temperature, as indicated by the pyrometer in the hot blast tube, must have its cause in a corresponding change of temperature in the furnace itself. The worst difficulties to contend with in this process occur when the charges have been so badly composed that a slag too thick or refractory to flow is formed. The tuyeres then have a tendency to "grow" together and the throat flame becomes incipient, bluish, and hot; if at the same time too little ore is charged. The remedy for this, until different charges have had time to come down into the hearth, is to increase the "driving," and if the temperature in the hearth becomes too great, the blast is introduced lower down between the walls, so that the slag by more imperfect reduction may become richer in iron, and consequently more fluid. On the other hand, if too much ore has been charged the temperature decreases and the throat flame becomes feeble and thin, the light from the tuyeres is less brilliant, and yellowish to reddish, and the unsmelted ore may be seen through the tuyere holes; the slag becomes yellow and sometimes red when tapped, besides very fluid owing to the large percentage of iron it contains. The bloom is then very porous and grows quickly but unevenly. Such abnormal operations of the furnace are corrected by the introduction of the blast higher up, and slow driving until the smaller ore charges have had time to come down.

THE LOSS OF IRON IN SLAG.

In all methods for the production of malleable iron, the indirect (different kinds of refineries), as well as direct, the loss of iron in the slag cannot be avoided, especially when the carbon used for fuel is in contact with the iron. In the direct methods, however, this loss is the greatest, and to this fact is due the chief drawback to the economical success of such processes. As the loss of iron in the slag in the direct production of malleable iron from the ores cannot be avoided, it is obvious that it must be greater the more earthy matter the ore contains. Another cause of loss of iron arises from the improper fluxing of the ore, as a greater quantity of FeO (protoxide), must be left unreduced in order to have the slag sufficiently fluid. In the old Harkhyttorna (furnace) no flux was used, and the only means of avoiding a higher carbonization than necessary to obtain malleable iron was to charge a sufficiently great excess of ore in order that the reduction may be incomplete, and the temperature in spite of the thick walls be so low that the reduced iron could not be more than necessarily carbonized. This practice was adopted during the development of the Husgafvel furnace, which however, has shown constantly a smaller loss of iron. It first became possible in the Wartsila furnace, and still more so in the Dobriansky furnace, to obtain with hollow walls the partial cooling down and regulating of the furnace, and thus conduct the process so that the ore has been more completely reduced without a higher carbonization of the blooms than is desirable. The loss of iron in the slag, however, in this furnace is greater with soft iron than where steel is produced, but that the percentage of iron in the slag when steely blooms are made need not necessarily be great, will be seen by the two analyses of slags from the furnace at Dobriansky, made in the laboratory of the department of the Ministry of Finance in St. Petersburg: The slags, when hard, somewhat steely, but malleable blooms were produced, contained FeO. 9.19, or metallic iron 7.15. When soft malleable iron was produced the slag contained on the other hand FeO. 52.46, or metallic iron 40.8. To judge of the efficiency of the reduction of the iron from the ore by the quantity of the iron which is found in the slag, is however, not possible, unless the composition of the ore and flux is well known. The loss of iron is most correctly determined by the differences between the iron contained in the ore and the quantity actually produced. If the magnetic iron ore of the Dobriausky is supposed to contain 58 per cent. of iron and 52.4 per cent. of metallic steely blooms are obtained from it, the loss then is as 5.6 is to 58, or $\frac{5.6 \times 100}{58} = 9.65$ per cent. The loss of iron in this case is thus about the same as in puddling. When soft iron was produced from the ore 50.2 per cent. of blooms were obtained, and the loss of iron thus became 13.44 per cent. When the softest kind of iron was produced from this ore 48 per cent. of blooms were obtained and the loss became 17.24.

THE ELIMINATION OF THE PHOSPHORUS WITH THE SLAG.

In direct methods the phosphorus, as is well known, is eliminated with the slag, and such is also the case here when iron low in carbon is produced. In this case nine tenths, or on an average two-thirds of the phosphorus in the ore may be eliminated with the slag, as the researches made at Wartsila have shown. But if it is desired to reduce the iron from the ore as completely as possible, then the greater part of the phosphorus is reduced combined with the iron, and when the ore is high in phosphorus the amount of carbon and phosphorus in the product grow side by side. The consequence of this is, that the blooms produced from phosphoric ores are most profitably worked up in the Siemens-Martin furnaces with basic linings.

PROSPECTS FOR THIS PROCESS.

As shown by the comparative results of the furnaces already constructed see plate], both the productive capacity and the economic results have gradually improved with the increased size of the furnace, and the reason that the size of the furnaces have increased slowly is owing to the general opinion of metallurgists that malleable iron cannot be produced in large furnaces. This opinion, however, has not been confirmed by the experience obtained with the Husgafvel furnaces. It is as possible to produce malleable iron from lake ores with the furnaces at Wartsila as with the old "hark" furnaces, and with the furnace at Dobriansky it is *more* difficult to produce from magnetic ores highly carburized steel than soft iron. There seems to be no doubt but that malleable iron could be produced with the Husgafvel furnace, even if it should grow to as large dimensions as the ordinary blast furnace now in use. The present dimensions of the Dobriansky furnace must be considered as the smallest which can be made with advantage for the treatment of refractory magnetic iron ores. In consequence of the nature of the process, it is obvious that the limit where an increase in the size of the furnace has ceased to be of advantage is sooner reached in the Husgafvel furnace than with an ordinary blast furnace. The direction in which one should go in order to obtain more advantageous results with this system is that already maintained, namely, an increase of the dimensions, and it is obvious that the shape of the furnace must be adapted to the materials which are to be treated. If, then, the question would be to produce iron for direct hammering or rolling, the materials must be subjected to a previous treatment in order to obtain as homogenous product as possible. The charcoal must be dried and assorted according to size, the ore well roasted and crushed as uniformly as possible.

Already at Dobriansky, where the furnace has been in operation but a short time, it has been possible to obtain 52.69 per cent. of shingled blooms from very refractory magnetic iron ores with a relative expenditure of charcoal [of 1.36 to 1 of iron], the conclusion may be drawn that steely blooms for the Siemens-Martin process can be manufactured as well from the ores known as Finnish lake ores and at a price no greater than pig iron, probably even less when the size of the furnace is increased. The Husgafvel method has besides the following advantages which the inventor claims to have especially advanced:

I. The cost of building is comparatively small and the furnace can work a long time without any considerable repairs.

II. By the number of furnaces the production can be adapted to general as well as local circumstances, whereby it should be observed that a greater number of furnaces not only decreases the cost of each furnace but also diminishes the cost of labor in running them.

III. The Husgafvel furnace can also be used for other metallurgic purposes, as, for instance, the calcining of dolomite, and the experiences at Wartsila, where such calcining was carried on for a considerable time in this furnace, has shown that the thin brick lining has stood well, although the heat in the furnace has been very high.

SUMMARY OF RESULTS OF CHR. HUSGAFVEL'S FURNACE AT DOBRIANSKIJ IRON WORKS, URAL, RUSSIA, 1886.

QUALITY OF THE MATERIAL USED.	Daily output of blooms, net tons		Percentage of blooms obtained from the ore.		Charcoal used for each 100 pounds of blooms, in bushels.		Weight of blooms in pounds.		Number of charges in 24 hours.		Charges—pounds.		Notes.
	Mean.	Highest.	Mean.	Highest.	Mean.	Least.	Mean.	Highest.	Mean.	Highest.	Charcoal.	Ore and flux.	
Magnetic ore from Maloblagodatj and mixed charcoal of ordinary and Siberian pine.													Welding (re-heating) and puddle slags have not been used long enough to obtain any reliable results. The temperature of the blast when the above results were obtained ranged from 200 to 235 C., but in some cases went as high as 300, and its pressure varied from 10 to 30 lines. Mercury.
Ore roasted and crushed to ¾ inch (up to October 1, 1886), ...	2.53	2.81	43.19	46.28	13.5	11.74	632.8	749.6	82	107	89.95	131.2-162.1	
Ore roasted and finely crushed to ¼ inch (in November, 1886), . . .	3.07	3.12	5 .8	52.4	12.50	12.07	674.6	793.6	92	104	89.95	134.9-148	
Ore unroasted and finely crushed to ¼ inch (in November, 1886), .	2.38	2.74	51.2	51.77	13.08	12.50	670.9	749.6	71	96	89.95	126.5-134.9	
Charcoal made in ovens from birch. Roasted ore of coarser kind, ¾ inch (before October 1, 1886), ...	3.03	3.21	41.62	45.68	9.53	9.14	746.8	796.5	61	70	134.9	193.0-202.4	
Unroasted ore of coarser kind, ¾ inch (before October 1, 1886), .	2.34	2.67	42.56	46.75	9.93	9.61	702.7	796.5	61	70	134.9	193.0-202.4	
Recently made mixed charcoal, 58 per cent. birch and 42 per cent. fir. Unroasted and finely crushed ore to ¼ inch, ...	3.22	3.37	51.17	52.69	9.36	9.14	807.7	862.0	73	75	126.5	178.0-187.4	
Roasted and finely crushed ore to ¼ inch (in November, 1886), .	3.28	3.35	51.27	51.61	9.06	8.21	790.8	815.2	72	73	126.5	178.0-196.8	
Cinder and mixed charcoal, . . .	2.67	3.02	59.1	62.0	11.17	10.35	833.6	937	71	82	89.95	131.9-143.4	

In translating and calculating the above table the following equivalents were used: Centner = 93.7 English pounds; tunna = 5.823 cubic feet or 3 66 bushels of 2748 cubic inches.

The following data refers to the plates, and by comparing results with the illustrations, which are made to a common scale, an idea of the progress made will be obtained:

	NAME OF FURNACE.					
	Porsaskoski. "A."	Porsaskoski. "B."	Pankakoski. "C."	Porsaskoski. "D."	Wartsila. "E."	Dobrianskij. "F."
Capacity, cubic feet,	30	90	115	175	230	400
Highest production in 24 hours, pounds,	937	2,342.5	3,748	3,748	7,795.8	6,840.1
Relative expenditure of charcoal,	2.80	1.40	1.10	1.12	1.05	*1.30
Greatest percentage of blooms obtained from the ore,	19	25	29	26	32	52.69
Per cent. of iron in ore,	35	35	37	35	36	58

*These results were obtained from charcoal made of 58 per cent. birch and 42 per cent. fir.

In addition to the translation of the paper, we present to our readers the following letter from Mr. Garrison :

"Having spent considerable time in the Ural during the summer of 1887, with numerous opportunities of observing the conditions affecting the Russian iron industries located there, and having had access to the books of the Dobrianskij Iron Works, I feel perfectly satisfied that the data given in the above paper is substantially correct; indeed I know the results have been improved in nearly every respect since this paper was written in 1886, the output of Husgafvel blooms not only being increased, but the quality and economy much improved. This has been chiefly due to the introduction of a new system of paying the furnacemen by piece-work and the naturally increased skill from constant practice in operating the furnace. It will doubtless be observed that the quantity of fuel given as necessary to produce a ton of blooms does not substantiate the inventor's claim to its economy in this respect.

"Although I think this claim rather broad, the peculiarly unfavorable condition in the Ural for the economical operation of any iron industry should be considered. The charcoal is not only produced from inferior material (Siberian fir), but it is wastefully and badly made. It is usually stored unprotected from the weather, and necessarily contains a large amount of moisture. The ore is also poorly prepared, and consequently contains much moisture. Finally the workmen, although naturally good, are so badly trained and managed that I doubt that, even if they had good machinery, etc., they could produce a much more economical product. To these conditions is also due the relatively better results obtained at the Wartsila furnace. The materials there are not only better prepared, but the workmen are much more skillful and the ore less refractory.

"When I first arrived at Dobrianskij the Husgafvel furnace was running on roll scale alone. At my request, however, it was changed to magnetic ore for a few days. From all that I could observe the product from each was about the same, perhaps, if anything, slightly better from the roll scale. Several shingled blooms of each were rolled into muck bars with the usual single heat and then made by the regular process into 'Russian plate.' On comparing this plate with that made from puddled iron I found that it contained not more than the usual amount of bad plates, but was besides much stronger and tougher, probably owing to its containing less sulphur.

"I did not see the newest and largest Husgafvel furnace at Petrozavodsk, on Lake Onega, but have been informed by reliable parties that its relative output is a considerable improvement upon even the more recent performances of the Dobrianskij furnace. The ore used at this place being high in phosphorus, the blooms are used in the Siemens-Martin furnace with basic linings in place of scrap, which is somewhat scarce and expensive. The same practice is carried out at Wartsila, the ore being about the same in both places. According to Z. Wasileffski, an engineer sent by the Russian government to investigate the Finnish iron industries (see Russian Mining Journal, February, 1887, page 307), the cost of pig iron at Wartsila is just about the same as Husgafvel blooms, although the latter requires about 10 per cent. more charcoal to make a ton of blooms; thus grey pig iron costs 32.62 kopecks and Husgafvel blooms 32.61 kopecks, or about $15.60 per ton.

(Signed) "F. LYNWOOD GARRISON,
"*Radnor, Pa.*

"DECEMBER 26, 1887."

Imports of Iron and Iron Ores.

The following data, excerpted from the report of the Bureau of Statistics, show the amount of some of the importations of special interest to the charcoal iron workers together with the countries from which they principally come, and the prominent ports of entry. The figures given are for the fiscal year ending June 30, 1887.

Pig Iron.--The imports of pig iron aggregated 418,918 tons, of which 279,150 tons came from England, 81,506 tons from Scotland, 47,169 tons from Germany, 2,300 tons from Spain. 1,696 tons from Belgium and 556 tons from Sweden and Norway. New York received 234,354 tons, against 58,101 tons for Philadelphia, 50,366 tons for Baltimore, 48,874 tons for Boston and

Charlestown, 9,962 tons for New Orleans and 8,670 tons for San Francisco.

Bar Iron.—The imports of bar iron were 37.036 tons, of which Sweden and Norway sent 28,819 tons: 3,487 tons came from Belgium, 1,890 tons from Germany and 2,434 tons from England. Of the bar iron imported New York received 19,813 tons, Boston 13,717 tons, Philadelphia 1,359 tons and San Francisco 976 tons.

Cotton Ties.—England controls the trade, its shipments to this country having aggregated 14,119 tons, the only other figure credited to any other country being 482 pounds from Germany. The Southern ports naturally received the bulk of the cotton ties imported; New Orleans reports 6,968 tons, Galveston 3,689 tons, St. Louis 1,109 tons, Charleston, S. C., 1,065 tons, Baltimore 672 tons and New York 617 tons.

Sheet, Plate and Taggers' Iron.—The imports were 7,537 tons, of which 5,417 tons came from England. The imports from Russia foot up to 2,033 tons; evidently representing the entire consumption in this country of genuine Russia sheet iron. New York received 4,921 net tons, Boston 982 tons and Philadelphia 1,034 tons.

Tin Plates.—The imports of tin plates were 286.110 tons, all of which came from England, with the exception of 3,069 tons from Canada, the latter, of course, merely in transit. Out of the total New York received 119.437 tons, Philadelphia 55.396 tons, Chicago 14,216 tons, Baltimore 39,907 tons, Boston 12,799 tons, San Francisco 13.298 tons, Buffalo Creek 892 tons, Cincinnati 682 tons. Huron 2,972 tons, Kansas City 3,274 tons, Milwaukee 1,763 tons, New Orleans 2,908 tons, Oregon 3,763 tons, Pittsburgh 1,225 tons, Portland Me., 4,409 tons, St. Louis 4,991 Calimut 1,039 tons and Yorktown, Va., 857 tons. To interior points the shipments were made in bond.

Wire Rods.—Out of the total imports of 161,269 tons, Germany heads the list with 97,376 tons. To this must probably be added the greater part of the 15,010 tons which came from the Netherlands. The extent of the use of the high grades of Swedish and Norway rods is clearly shown by the export figures from that country, which aggregate 25,482 tons. Belgium has 13,475 tons and Great Britain only 9,860 tons. New York received 123,853 net tons, Boston 14,212 tons, Pittsburgh 8,841 tons, Baltimore

4,498 tons, St. Louis 4,429 tons, Philadelphia 2,859 tons, New Orleans 1,372 tons and San Franciso 1,204 tons.

Iron Ore.—The imports of iron ore amounted to 1,141,774 tons. Of this 522,719 tons, came from Spain; Africa followed with 215,760 tons, Italy with 111,423 tons and Cuba with 109, 928 tons; 72,546 tons came from England. 44,173 tons from Greece, 18,430 tons from Canada, 13,613 tons from Turkey in Asia and 10,122 tons from Portugal. There were received at Philadelphia 622,352 tons, Baltimore 394,407 tons, New York 54,895 tons, Perth Amboy 40,441 tons.

◆

THE displacement of iron by steel is an old story upon which the changes have been rung so long that it would seem as if there was very little new to be said. The enthusiastic advocates of steel, who supposed years ago that the widespread use of steel for rails indicated the early abandonment of iron in all rolled forms have been disappointed in the comparatively slow progress that has been made in this direction. On the other hand, the stubborn advocates of iron, who insisted that steel might do well enough for rails, but that there were numerous reasons why it would not make much headway in other lines, have seen the change come faster than was altogether pleasant to those who had large iron interests at stake. The ebb and flow in the demand for rails have had much to do with this steel question. The years in which the demand for rails has tested the utmost capacity of the Bessemer steel rail mills have been propitious for the iron mills making merchant shapes, while the years of dullness in the rail trade have seen rapid inroads made upon the trade of the iron mills, and large steel works have latterly been built for the express purpose of making products which were once made exclusively of iron. The decreased demand for rails which is now being experienced indicates the approach of another period of wider encroachment upon iron.—*Iron Age.*

◆

OWING to the fact that all of the States represented in the Association have not reported names for the board of managers, only the officers and the executive committee are given on the inside of the front cover. As soon as the complete nominations are obtained the secretary will issue a list of the board. A new roll of members will also be prepared and published.

N. H. Langdon
Port Henry
N.Y.

Vol. 7. 1888. No. 6

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JOURNAL

OF THE

UNITED STATES ASSOCIATION

OF

Charcoal Iron Workers.

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1888.

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OF

CHARCOAL IRON WORKERS.

Devoted to discussing and illustrating improvements in iron metallurgy, or in the manufacture of charcoal.

It is mailed, post paid, to each MEMBER and ASSOCIATE of the UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS, Or can be obtained for an *Annual Subscription of $3 00.*

Edited by JOHN BIRKINBINE, Secretary,
No. 25 N. E. City Hall Square. **(N. Juniper St.),**
Philadelphia, Pa.

ARTICLE V.—Constitution of the United States Association of Charcoal Iron Workers.

Any person practically engaged, or interested, by reason of capital invested, in making or using pig iron or blooms made with charcoal may become a MEMBER of the Association by paying an annual fee of five dollars ($5): *Provided,* That each iron works represented shall pay not less than ten dollars ($10) per annum into the treasury.

Persons not engaged in making or using charcoal pig-iron or blooms may become ASSOCIATES, without the right to vote or hold office, upon the payment of an annual fee of five dollars ($5) each. All fees to be due when the membership is applied for and thereafter on the first day of October in each year, being in advance.

All communications should be addressed to the Secretary of the Association.

Pig Iron Statistics.

It has been our practice to present to the readers of the JOURNAL annually, an analytical resumé of the pig iron statistics as prepared by Mr. James M. Swank, for the American Iron and Steel Association; and in the following tables we have endeavored to invite attention to such features as we believe will be of service to our readers for reference, and, also, as a guide for the consideration of the relative importance of the industry in various portions of the country.

In a discussion of "The status of charcoal pig iron," in the JOURNAL, Vol. VII, pages 210 to 221, will be found statistical tables showing the production of pig iron by various fuels, from 1854 to 1886, both inclusive, with the percentages of the total represented by each fuel; also, the percentages of increase or decrease in production since the organization of the United States Association of Charcoal Iron Workers, also the output of the various districts into which are grouped the blast furnaces using charcoal, and the percentage produced by each for the same period, as well as other data believed to be of value. It will be unnecessary to repeat these tables, except such portions as are essential to make the present article complete, and those who desire to compare results can do so by referring to the editorial upon "The status of charcoal pig iron."

The year 1887 stands in advance of any other in pig iron production, the total output being 7,187,206 net tons, or 6,417,148 gross tons, an increase of 7.8 per cent. over the figures for 1886 Never before was so much iron made with mineral fuel, but the product of the charcoal blast furnaces in 1887 was exceeded in the years 1881 and 1882, and closely approximated in the years 1873 and 1874. Notwithstanding this, the proportionate output of charcoal pig iron to the total make, shows an improvement over 1886 as exhibited by the following:

Percentages of total pig iron production,

	1886.	*1887.*
Made with anthracite fuel,	32.99	32.53
Made with bituminous fuel,	59.79	59.42
Made with charcoal,	7.22	8.05

The following statement shows the relation between the production for the year, and the stocks of unsold pig iron at the close of 1887.

FUEL USED.	Pig iron made in 1887. Net tons.	Stocks of pig iron, Dec. 31, 1887. Net tons.	Percentage of stock to product.
Charcoal,	578,182	95,532	16.5
Bituminous,	4,270,635	127,978	3.0
Anthracite,	2,338,389	114,107	4.8
Total,	7,187,206	337,617	4.7

The same relative data applied to the charcoal pig iron industry, divided by districts shows as follows:

The Northern district includes the furnaces of Maine and northern and central New York.

The Salisbury district embraces the furnaces in Connecticut, Massachusetts and south-eastern New York.

The Pennsylvania district, furnaces in Pennsylvania.

The Baltimore district comprises the furnaces in Maryland, Virginia and West Virginia.

The Southern district embraces the furnaces of Alabama, Georgia, Tennessee, North Carolina and part of Kentucky.

The Hanging Rock district, of Ohio, and Kentucky.

The Lake Superior district embraces the furnaces using Lake Superior ores, including all in Michigan and Minnesota, and a part of those in Wisconsin and those of north-western Ohio.

The Western district, all charcoal furnaces west of the Mississippi river.

DISTRICTS.	Pig iron made in 1887. Net tons.	Stock on hand December 31, 1887. Net tons.	Percentage of stock to product.
Northern,	15,679	4,447	28.5
Salisbury,	48,064	10,860	22.6
Pennsylvania,	11,910	8,876	74.5
Baltimore,	24,910	1,772	7.2
Southern,	145,787	15,000	10.3
Hanging Rock,	22,745	6,284	27.6
Lake Superior,	262,366	40,132	15.3
Western,	46,721	8,181	17.5
Totals,	578,182	95,532	16.5

The stocks of charcoal pig iron on hand at the close of the years 1880, 1881, 1882, 1883, 1884, 1885, 1886 and 1887, represented the following percentages of the total production of charcoal pig iron in the years named:

Stock	at close of	1880	represented	17.8	per cent.	of the year's	production.
"	"	1881	"	13.1	"	"	"
"	"	1882	"	23.6	"	"	"
"	"	1883	"	32.1	"	"	"
"	"	1884	"	48.4	"	"	"
"	"	1885	"	50.7	"	"	"
"	"	1886	"	28.6	"	"	"
"	"	1887	"	16.5	"	"	"

Of the total stocks of 'pig iron on hand at the dates above named, the percentages represented by charcoal iron were,

Stocks of charcoal pig iron.	January 1, 1881,	21	per cent.	of total stock.
	January 1, 1882,	39.8	"	"
	January 1, 1883,	38.4	"	"
	July 1, 1883,	27.5	"	"
	Nov'ber 1, 1883,	33.5	"	"
	January 1, 1884,	34.4	"	"
	January 1, 1885,	37.4	"	"
	January 1, 1886,	55.8	"	"
	January 1, 1887,	52.1	"	"
	January 1, 1888,	28.3	"	"

The geographical distribution for six years of the stocks of unsold charcoal pig iron was:

STATES.	TONS OF 2,000 POUNDS.					
	Jan. 1, 1883.	Jan. 1, 1884.	Jan. 1, 1885.	Jan. 1, 1886.	Jan. 1, 1887.	Jan. 1. 1888.
New England,	9,866	12,437	11,433	8,697	9,218	7,930
New York,	12,550	17,207	17,426	16,539	6,132	7,357
Pennsylvania,	10,241	11,336	14.297	13,452	12,905	8,876
Maryland,	5,543	6,399	5,734	8,762	4,755	1,167
Va., N. C., Ga. and Texas,	19,182	14.434	20,326	22.510	8,122	3,678
Alabama,	16,622	6,731	10,900	10,530	2,892	10,320
Kentucky,	7,264	6,916	5,524	4,319	3,718	3,074
Tennessee,	10,460	18,061	19,448	17,967	8,888	2,900
Ohio,*	28,314	25,221	19,441	21,412	12,438	4,410
Michigan,	27,073	35,678	60,715	67,779	41,953	39,319
Wisconsin,	5,801	6,340	7,366	4,998	6,002	13
Missouri,	12.323	17,891	24,328	20,373	7,022	5,329
Pacific States,	....	5,327	5,224	5,707	6.232	1.159
Total,	165,239	183,978	222,162	232,352	131,567	95,532
*Hanging Rock Dis't of O.,	27.486	24,236	18,726	16,361	10,128	3,610

Analyzing the production of charcoal pig iron in 1887 we find that the Lake Superior district increased its product 43,000 tons over 1886, and came within 13.000 tons of the maximum output of 1882, carrying over to 1888 slightly less than the average stock of the charcoal furnaces throughout the country.

The Southern district continues second in importance, having excelled all other years. the figures for 1887 being 33,000 tons in advance of 1886, and 29,000 tons in advance of 1885, which had been the maximum. It is probable that the output of 1888 will be still greater, as there are new furnaces to be put in blast, and the stock of pig iron carried over is proportionately small.

The Salisbury and Western districts hold relatively the same positions as producers (third and fourth), as in 1886, but although the Salisbury district increased its production over 6,000 tons, the Western district added nearly 19,000 tons to the output of 1886. While each district holds stocks above the average, the proportion in the Western district is smaller than that in the Salisbury district. We shall not be surprised if these two districts change places in the order of prominence in 1888, but it is doubtful if either will reach the maximum of 61,582 tons for the Salisbury district in 1881, or 63,442 tons for the Western district in 1882.

The Baltimore district in 1887 nearly doubled its record of 1886, and exceeded by 2,000 tons that of 1885, thus rising from seventh to fifth place, and carried over to 1888 less stock proportionately than any other district. But the figures for 1887 are less than one-half of the maximum (54,410 tons) in 1882.

The Hanging Rock district follows the Baltimore district, but shows practically the same output in 1887 as in 1885 and 1886. While the Northern district comes next with an output treble that of the preceding year, and approximating the maximum of 1881. More than one-fourth of the year's product of these districts was carried over to 1888.

The group of Pennsylvania charcoal furnaces shows the most unsatisfactory condition, the production in 1887 having been less than for many years, and three-fourths of the output was carried over to 1888. As a producer of charcoal pig iron, Pennsylvania is rapidly declining, and will continue to do so unless more modern plants are built, and economical methods of charcoal manufacture are adopted.

The march of improvement which has kept Pennsylvania at the lead of pig iron producers has been maintained by the furnaces using mineral fuel, for the output of charcoal pig iron in the state in 1887 was but one-fifth of what it was in 1881.

We may now study the geographical distribution of the pig iron industry.

Of the total production of pig iron with all kinds of fuel in 1887,

	Per cent.
Pennsylvania—is credited with,	51.3
Ohio,	13.6
Illinois,	7.0
New York,	4.1
Alabama,	4.0
Tennessee,	3.5
Michigan,	3.0
Leaving for the 16 other States which were producers in 1887,	13.5

Divided sectionally, the percentages were,

	Per cent. of total.
New England States, (Maine, Massachusetts and Connecticut),	0.5
Middle States, (New York, New Jersey, Pennsylvania and Maryland),	58.3
Southern States, (Virginia, North Carolina, Georgia, Alabama, Texas, West Virginia, Kentucky and Tennessee,	12.4
Western states, (Ohio, Indiana, Illinois, Michigan, Wisconsin, Missouri, Colorado and Washington Territory),	28.8

Of the total product of pig iron there was made,

East of the Mississippi river,	97.6
West " " "	2.4

The output of the blast furnaces east of the Mississippi river was divided as follows,

North of the Ohio and Potomac rivers,	84.8 per cent.
South " " "	15.2 per cent.

Of the product of charcoal pig iron in 1887,

	Net tons.		*Per cent. of total.*
Michigan made,	213,543	=	36.9
Alabama "	95,223	=	16.5
Wisconsin "	47,523	=	8.2
Tennessee "	46,224	=	8.0
Missouri "	40,752	=	7.0
New York "	26,491	=	4.6
Connecticut made,	21,741	=	3.8
Leaving for the other ten active states,	86,685	=	15.0

By districts the output was,

	Net tons.		*Per cent. of total.*
Northern district,	15,679	=	2.7
Salisbury district,	48,064	=	8.3
Pennsylvania district,	11,910	=	2.1
Baltimore district,	24,910	=	4.3
Southern district,	145,787	=	25.2
Hanging Rock district,	22,745	=	3.9
Lake Superior district,	262,366	=	45.4
Western district,	46,721	=	8.1
Total,	578,182	=	100.0

Having indicated the relation between the product of 1887 and stocks of pig iron carried over, we naturally look to the actual consumption of pig iron in the country as a gauge of our progress and an indication for the future. The following table has been prepared to indicate the apparent consumption of pig iron for thirteen years. To the stock carried over from a preceding year is added the domestic pig iron made and the foreign pig iron imported, from their sum (representing the available supply) the stocks held at the close of the year are deducted to obtain the consumption. The figures given are for all kinds of pig iron, and an examination of the component parts of each statement will indicate that in no single year has the production equaled the consumption; thus giving decidedly negative testimony to the theory of over-production. Maxima are indicated by full-face figures.

As the importations of charcoal iron are not separately reported, the apparent consumption is based upon the make of domestic pig iron, plus or minus the excess or deficiency of stock at the close of the years named.

	Stock of pig iron from previous year.	Production of pig iron for the year.	Importations during the year.	Total available supply of pig iron.	Deduct stock of pig iron on hand December 31.	Consumption apparent.
	Net tons.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*
1875,	**795,784**	2,366,581	83,932	3,246,297	**760.908**	2,485,389
1876,	760,908	2,093,236	83,072	2,937,216	686,798	2,250,418
1877,	686,798	2,314,585	66,861	3,066,244	642,351	2,423,893
1878,	642,351	2,577,361	74,484	3,294,196	574,565	2,719,631
1879,	574,565	3,070,875	340,672	3,986,112	141,674	3,844,438
1880,	161,674	4,295,414	**784.968**	5,222,056	456,658	4,765,398
1881,	456,658	4,641,564	520,835	5,619,057	210,896	5,408,161
1882,	210,896	5,178,122	604,978	5,993,996	429,694	5,564,302
1883,	429,694	5,146,972	361,366	5,938,032	533,800	5,404,302
1884,	533,800	4,589,613	206,381	5,329,794	593,000	4,736,794
1885,	593,000	4,529,869	164,349	5,287,218	416,512	4,870,706
1886,	416,512	6,365,328	405,180	7,187,020	252,704	6,934,316
1887,	252,704	**7,187,206**	523,625	**7,963.505**	337,617	**7,625,918**

In like manner we find that the apparent consumption of charcoal pig iron from 1875 to date, is as follows:

Year.	*Apparent consumption net tons.*
1875,	420,624
1876,	384,958
1877,	316,177
1878,	336,443
1879,	507,817
1880,	495,440
1881,	650,958
1882,	616,717
1883,	552,987
1884,	420,234
1885,	383,936
1886,	475,275
1887,	**715,002**
Average for 13 years,	482,813

The following table illustrates the relative importance of each State as a producer of charcoal pig iron in 1887 and the product in that year; as compared with the product reported since 1879, the maxima being in full-faced figures. Corresponding data for the years 1872 to 1878, both inclusive, will be found in JOURNAL Vol. VII, page 18.

Production of Charcoal Pig-Iron from 1879 to 1887, by States.

STATES.	TONS OF 2,000 POUNDS.								
	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
Maine,	1,240	3,578	4,400	4,100	4,000	......	440	**5,060**	4,397
Vermont,	625	1,800	**2,796**	1,210	......	......	......	......	......
Massachusetts,	5,010	9,862	**12,360**	10,385	10,769	4,902	869	8,124	11,114
Connecticut,	16,759	22,548	**28,483**	21,348	19,976	14,174	17,500	19,390	21,741
New York,	18,129	27,844	30,467	**30,716**	25,680	23,488	14,682	14,380	26,491
Pennsylvania,	35,896	43,374	**51,908**	49,975	38,315	28,155	12,148	16,727	11,910
Maryland,	19,734	**33,050**	27,626	28,277	23,807	15,123	10,492	7,872	15,454
Virginia,	7,708	14,043	19,038	**26,133**	16,879	14,829	12,618	6,069	9,456
North Carolina,	......	......	800	1,150	......	435	1,790	2,200	**3,640**
Georgia,	4,133	7,277	13,404	**15,565**	18,054	9,615	5,797	459	......
Alabama,	31,991	37,737	44,221	55,541	57,385	59,448	77,573	82,110	**95,223**
Texas,	400	2,500	3,000	1,321	2,981	**5,140**	1,843	3,250	4,383
West Virginia,	200	**3,245**	1,200	......	......	......	......	......	......
Kentucky,	12,736	**21,174**	16,778	17,165	13,981	7,882	4,707	6,863	6,201
Tennessee,	7,567	16,675	19,046	37,611	35,299	18,806	31,173	27,402	**46,224**
Ohio,	43,445	**69,190**	66,169	58,654	40,528	24,880	18,018	16,161	18,544
Indiana,	......	2,000	......	......	......	......	......	......	......
Michigan,	101,539	154,424	187,043	210,195	178,185	172,831	143,121	190,731	**213,543**
Wisconsin,	31,430	42,913	47,702	**55,369**	39,349	25,812	19,629	28,487	47,523
Missouri,	17,887	15,769	43,241	**54,327**	34,112	31,558	21,785	20,127	40,752
Oregon,	2,500	5,000	6,100	6,750	**7,000**	3,640	8,832	......	......
Minnesota,	......	3,520	7,442	**8,126**	8,100	......	......	......	......
Utah,	......	......	......	57	......	......	......	......	......
California,	......	......	4,414	987	**5,327**	2,157	......	1,750	......
Washington Territory,	......	......	1,200	......	2,317	540	1,857	**2,842**	1,586
Total,	358,873	537,558	638,838	**697,906**	571,726	458,418	399,844	459,557	578,182

TOTAL IRON PRODUCTION ACCORDING TO FUEL USED.

	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
Anthracite coal,	1,273,024	1,807,651	1,731,462	2,012,138	1,885,596	1,586,453	1,454,390	2,099,597	**2,338,389**
Charcoal,	358,873	537,558	638,838	**697,906**	571,726	458,418	399,844	459,557	578,182
Bituminous coal and coke	1,438,978	1,950,205	2,268,264	2,438,078	2,689,650	2,544,742	2,675,635	3,806,174	**4,270,635**
Total,	3,070,875	4,295,414	4,641,564	5,178,122	5,146,972	4,589,613	4,529,869	6,365,328	**7,187,206**

Physics versus Chemistry—Reflection on Blast Furnace Practice.

By MR. SAMUEL D. MILLS.

It is a difficult matter to draw the line between the respective departments of physics and of chemistry in the matter of blast furnace practice, but it is evident, nevertheless, that some of its phenomena belong to the realm of physics, and it is questionable whether the influence of chemical action is not now overrated to the partial exclusion of physical considerations. Nearly all blast furnaces are now supplied with the required stocks of ores based on the chemical analysis chiefly, the physical character of the ores not being sufficiently taken into consideration. It is a well-known fact that the rate of deoxidation in the furnace and the rate of carburization differ very materially for different ores, and not only for different ores but for different varieties of the same ore, for ores, nominally the same and taken from the same shaft or lead, often vary greatly in physical characters, as density, form of fragments, etc., while the chemical composition may remain almost constant. This is a matter which frequently does not receive the consideration it deserves. We find magnetic ores from the same mine, some massive, other portions coarsely crystalline or perhaps granular and loosely aggregated, so that they fall into sand at the slightest blow. The so-called specular ores vary in like manner from the beautiful mirror-like crystals of the true specular to the earthy-looking ore with splintery fracture, ordinarily known as specular. Then we have the micaceous ores, almost identical in composition with the specular and the red hematites also, almost, if not quite, undistinguishable from either of the foregoing by chemical analysis. After these come the brown or hydrated hematites, which differ but little from the preceding, except in the quantity of combined water they contain, yet, after roasting, when they have by that means been brought to the same chemical condition as the anhydrous ores, experience shows that their action in the blast furnace is of a very different nature, and that this difference is greater or less according to the amount of roasting to which they have been subjected. We have then a variety of descriptions of ore differing in their physical condition or structure, these differences having little relation to their chemical characteristics. In some cases (I have noticed it especially in the Lake Superior and Canadian magnetites) there are differences which we might suppose were caused by variations in the metamorphic action, which gave birth to these deposits, but frequently we find the change in the structure of the ore, occurring in such a manner as to preclude the possibility of such difference of action either in original deposition or in the subsequent metamorphism.

What then causes the difference? What is the nature of the force which governs crystallization and determines the various forms of the minerals? We know not, neither is our knowledge so positive respecting the so-called elementary bodies as to enable us to say positively whether any one of them is certainly elementary in its nature and not merely a compound, which, up to the present, has resisted all attempts to decompose it. If iron is of this nature, may it not carry with it through the action of the blast furnace certain peculiarities which affect its structure as pig iron? This much we do know: That the opinion of a chemist who had analyzed a sample of an ore would not be a safe guide to take as to the working of that ore in the furnace. We often see that the opinion of a practical furnaceman, even if he is ignorant of chemistry, is the safer guide of the two, and neither of them can indicate what sort of chill any mixture of ores will give until it has been tried. Being somewhat of a chemist I have no desire to undervalue the chemist's labors, but believe that "there are more things in heaven and earth than are dreamed of in our philosophy," and I would, therefore, like to know if the readers of the JOURNAL have noticed peculiarities in the relation between the structure of their ores and their working in the blast furnace; if so, I am sure they could give some interesting information without running the risk of giving away those bits of private "wrinkles," which every furnaceman supposes himself to be possessed of by right of discovery.

The more we have to do with pig iron the more we become impressed with the great range of difference in structure, color strength and other properties which confront us, to the greater portion of which chemistry offers only an uncertain explanation, as is clearly stated in the very interesting paper by Mr. Fleming, in the last number of the JOURNAL. This is especially noticeable in car-wheel iron, for in it we have a complicated problem to deal with. In other irons the desiderata are tensile and torsional strength and resilience, also a proper degree of fluidity for casting and regularity of shrinkage, while in the car wheel we have added to these the necessity for a chill which, together with hardness for wearing, will combine immunity from cracking and possess that peculiar crystalline structure needed to insure, along with these qualities, perfect safety from risk of splitting away from the unchilled portion of the wheel. This matter appears to be on the border land between physics and chemical science, but probably belongs to the former, for though it is necessary to have the proper chemical composition of the mixture of ores in order to obtain any chill at all, yet the nature of the chill is greatly influenced by purely physical circumstances, as, for instance, the intensity of the blast, i. e., the velocity which it possesses at the nozzle of the tuyere; size of tuyere used, etc.; or a change of ore, even though the change may make no difference in the composition of the charge. I know of two high grade ores very low in silica, phosphorus and sulphur, (hardly a trace of the latter), almost identical in their analyses, yet on an 1,800 pounds charge, 900 of one ore can be used, while anything over 100 pounds of the other ore will completely spoil the chill, making it full of cleavage lines nearly parallel to the face of the chill and giving it a fanciful resemblance to the ore which frequently is full of similar short cleavage lines. The physical structure of these two ores is widely different. I have analyzed both and failed to detect anything that would account for this difference in their action, and apart from this peculiarity about the chill they both make good iron.

I have alluded to the difference in the rate of deoxidation and of carburization in different ores and in varieties of the same ore, a matter which appears to receive little attention; the brown hematites and similar soft ores are easily acted on by the reducing gases in the furnace, and all ores differ more or less in this respect; yet we see hard compact magnetites, slaty, splintering hematites, and brown hematites that hardly require crushing, all put through the same ore crushers; the latter ores are almost pulverized, the magnetites come through in cuboidal blocks, and the slaty hematites pass through untouched in pieces as large often as an open hand. Now if in order to secure even working and full control of the furnace, we should have the ores as nearly as possible *all equally carburized before reaching the zone of fusion;* what possibility is there of doing so, under such conditions? The soft ore is carburized before it gets two-thirds of the way through the furnace. The magnetite manages to get through on time, while the slaty hematite taking advantage of its slimness, like thin men in crowds, frequently distances the other two and makes its appearance in front of the tuyeres in a raw or at best half cooked condition. A mixture of ingredients is all very well for soup, but with pig iron the case is somewhat different; it is a matter of commercial necessity, not of taste.

According to some authorities the chill of an iron depends upon the temperature of the blast furnace at that point where fusion takes place, this is doubtless correct so far as depth of chill or grade of iron is concerned, but it is evident that the quality of the chill is independent of this or rather is decided by other circumstances. It appears probable that there are various temperatures in various parts of the zone of fusion at the same time, this would account for the fact that we get in the same cast different grades of iron, the denser grades separating by their greater specific gravity and settling at the bottom of the crucible. In many cases we find a considerable difference between the grade of iron that runs first from the iron notch and the last bed cast without any change having occured in the working of the furnace that would suffice to cause the difference. It may be that this variation is increased by a separation of the silicon mingled with the iron in the bottom of the crucible, the difference in the specific gravity would tend to effect this; silicon being 2.49 as against 7.8 for iron; it would thus separate from the lower layers of iron either as free silicon or as carbide, and so rise to mingle more abundantly with the upper portion, making it richer in silicon and free the carbon. In this view of the case I am taking the generally received opinion that the less silicon there is in iron the harder it will be, on account of a greater proportion of the carbon being in the combined state, whereas if there was more silicon present the carbon would be forced to assume the free or graphitic condition, so giving a softer iron, but this opinion is not always correct, as may be seen by the following analyses taken from Sir I. L. Bell's Principles of Iron Manufacture:

GRADE OF IRON.	No. 1.	No. 2.	No. 3.	No. 4.
Graphitic carbon,	3.421	3.155	3.361	3.308
Combined carbon,	.583	.581	.393	.319
Total carbon,	4.004	3.736	3.754	3.627
Silicon,	1.708	1.646	1.382	1.381
Manganese,	1.606	1.472	1.475	1.169
Sulphur,	.073	.070	.063	.081
Phosphorus,	.630	.635	.602	.602
	8.021	7.559	7.276	6.860
Iron,	92.070	92.644	92.952	93.292
	100.091	100.203	100.228	100.152

Here the combined carbon is actually lowest in the highest grade iron (No. 4), the silicon being also less in the highest grade it is simply the purest, and is higher in *graphitic carbon* than the No. 2. Reasoning from this one would be led to the conclusion that the purer the iron the harder it would be.

Is the cause of the difference in grade in this case physical or chemical? Or are we to suppose that the grade is here governed by the variation in the silicon and manganese without any regard to the quantity or condition of the carbon? The phosphorus and sulphur have evidently nothing to do with it. It is an old saying that "circumstances alter cases," probably it holds good here, and the quality of iron is determined by the quantity and condition of the carbon at all times, *unless it is determined by something else*; this seems to be about the amount of our knowledge on the subject. There are so many conflicting influences at work that it is difficult to lay down any general rule that shall hold good at all times, but every advance made towards ensuring regularity in physical condition, must simplify the problems submitted to the chemist for solution.

This paper is full of suggestions for our readers and although we do not agree in all of Mr. Mills' conclusions, we recognize the value of considering the subject from his standpoint, and hope others will pursue the topic further. In connection with Mr. Mills' paper we invite the attention of our readers to excerpts from a lecture delivered at the Franklin Institute, by Mr. A. E. Outerbridge, of Philadelphia. The lecturer having been associated with one of our large car wheel manufacturing works, naturally treats of chilling irons and the adaptability of various grades of pig iron for foundry use. For convenience these excerpts have been placed immediately following Mr. Mills' paper, but are presented as a separate article. The two papers make, with that of Messrs. Fleming and Keep [Vol. VII, page 242], valuable additions to our literature upon properties of cast iron..—ED.

Relation Between Physical Properties and Chemical Constituents of Pig Iron.

By ALEX. E. OUTERBRIDGE, JR.*

* * * The fuel formerly used in blast furnaces was charcoal, and the quality of the metal (called "pig" iron, from the shape into which it is cast as it runs from the furnace) was far superior, for certain special uses, to that made by modern processes.

I do not mean to say that I think this is necessarily so, or that it will always be true, but am compelled to admit that, at this stage of evolution in the iron industry, modern improvements have all been in the line of increased output from a furnace with decreased consumption of fuel, but at the expense of the character of the metal and consequent depreciation of value. * * *

Pig iron varies so greatly in general appearance, color, hardness, ductility, tensile and transverse strength and specific gravity, that one not having expert knowledge upon the subject, might reasonably doubt that the specimens exhibited on the accompanying plate, even belong to the same class of metal. One specimen is soft and ductile like lead, and shows a rich, dark color and coarse granular fracture; another is hard as steel, brittle as glass, and white as silver, while between these extremes we have a great range of specimens having intermediate qualities.

A photograph was taken from a series of "test pieces," (of which *Figs.* 1 *and* 2 are reproductions) made from different grades of pig iron, in moulds of uniform size, cast in "green sand," against an iron "chill plate" for the purpose of suddenly cooling one side of the casting. The pieces are arranged in a series with the chilled side uppermost, beginning with a sample which shows no tendency to produce white or chilled metal, and passing. by gradual steps, to metal which crystallizes as white iron through the whole mass. All of these specimens were cast from iron which was perfectly gray in the pig, sufficiently soft to bore readily, varying but slightly in specific gravity, and ranging in transverse strength from 5,000 to 7,000 pounds per square inch. The effect of sudden cooling has developed the white crystalline structure in some of the specimens, rendering them so hard that they cannot be touched with a file, and so brittle that they may be readily broken, and increasing their density to such a degree that a cubic foot of the white metal weighs nearly sixty pounds more than an equal bulk of the gray iron.

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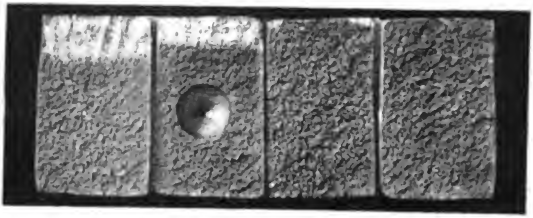
*Vide Franklin Institute Journal Vol. CXXV., page 223, March, 1888.

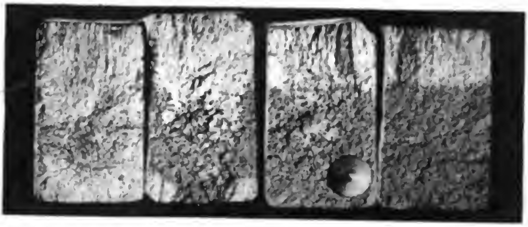
Very little information has been printed in regard to the wide differences in the character of *white iron*, although it is a subject of great practical importance to the manufacturer of chilled castings, and it will, no doubt, surprise many to learn that I have found, as the result of a series of careful experiments, that there is as a wide difference in the strength of different specimens of white iron as in those of gray iron. Moreover, there is a vast difference in the ability of white iron to resist disintegration or "spalling" under the repeated impact of hammer blows, dependent upon the molecular structure of the crystals. There is also a decided difference in the density, or specific gravity, and hardness of different specimens of chilled or white iron.

Fig. 3 is a photograph taken from a series of chilled iron test pieces, which were cast in iron ingot moulds made for these original experiments, in which you may observe several interesting features. The samples were all cast from gray iron, some of which showed no tendency to produce white iron when cast in the ordinary "chill moulds," yet in these small ingot moulds they are chilled throughout the mass. You will observe quite a difference in the molecular arrangement and size of the crystals, and what is still more singular, you will see in all of the square sections a plainly marked cross, or dividing lines, extending from corner to corner of the ingot. White iron always crystallizes in planes at right

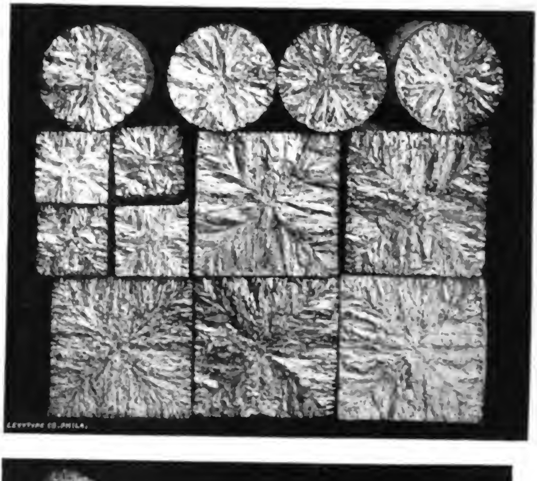
1



2



3



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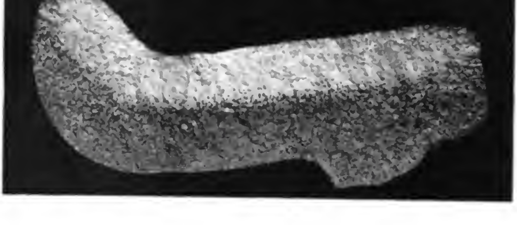

angles to the chilling surface, and, as the moulds are made of iron, the crystals start from all four sides at the same instant, and meet at points equi-distant from the surface, which may be called the neutral line. By splitting some of the ingots lengthwise, I have found this line extending, plainly marked, through its entire length. It is an interesting phenomenon that the line of demarcation of opposing crystalline forces should be so clearly defined. It will be noticed in the specimens cast in the cylindrical moulds, that the crystals radiate from the center like the spokes of a cart wheel. Some of the specimens here shown are so brittle that the slightest tap from a light hammer will break them, while others of the same diameter require more than 100 blows to break. Some of them are much harder than others, while the difference in density amounts to nearly ten pounds to the cubic foot, as ascertained by specific gravity determinations. * * *

The chemistry of iron, in its connection with the manufacture of Bessemer steel, has, from the necessities of the case, been carried to a fine degree of perfection, but it is a matter of surprise that so little is known practically in the foundry and workshop, in regard to the cause of these wide variations, which are a frequent source of difficulty in manipulation of the metal, and loss of time, money and labor. The subject is, however, beginning to attract a share of the scientific attention which has been bestowed upon the chemistry of steel, and upon which the success of that industry so largely depends. * * *

Manufacturers are beginning to realize that pig iron is not a simple substance, but is in reality an alloy, composed of a number of dissimilar elements; that its physical characteristics, such as strength, elasticity, etc., depend upon the percentages of these constituents, and that pure iron, like pure gold, is always the same thing physically and chemically, no matter from what source it may be obtained. We believe that the time is coming when pig iron will be sold on its chemical analysis, instead of on the crude methods of grading, at present in vogue, and farther, that, as the naturalist can accurately tell the *genus* of an animal from an examination of a single bone, so the analyst will tell the physical qualities of a mass of iron from an analysis of its component parts.

The great differences observed in physical characteristics of pig iron are due, not to variation of the proportion of iron in the pig (which remains constant within a few points), but to the varying percentages of the other component elements, viz., carbon, silicon, sulphur, manganese and phosphorus, and experience has proved that a change of less than one-half of one per cent. of one of these elements (silicon) is sufficient to make or mar the daily product of at least one important iron industry, viz., the manufacture of chilled cast-iron car wheels.

We will briefly consider the effect upon pig iron of these foreign elements in the order of their relative importance.

The element which exerts the most vital influence upon the character of pig iron is carbon. This is strikingly shown by Mr. Fairbairn, who says:

"The metal in the form of cast iron, containing four per cent. of carbon, has a tensile strength of 18,000 pounds to the square inch, and is worth £3 per ton. Deprive it of this four per cent. of carbon and it becomes malleable iron, with a tensile strength of 56,000 pounds, and is raised in value to £8 per ton. But leave in it one per cent. of the carbon it originally contained, and it will have a tensile strength of at least 130,000 pounds, and its selling price rises to £50 per ton." This price, of course, refers to crucible steel at the time he wrote.

Carbon exists in pig iron in two distinct forms, and upon the relative proportion of each depends, in great measure, the character of the metal. It is present either in the form of graphite or free carbon, disseminated throughout the mass in black shining particles, in which case the iron is exceedingly soft and ductile; or it is in part or wholly combined chemically with the iron, causing the metal, when cooled suddenly, to crystallize in parallel planes, presenting a perfectly white fracture, and the metal becomes harder than steel and extremely brittle; advantage is taken of this peculiar quality in the production of chilled castings, as in cast-iron car wheels, ploughshares, etc.

Cold-blast charcoal iron contains a larger proportion of combined carbon than warm-blast charcoal, anthracite, or coke iron, hence its peculiar value for chilled work.

Pig iron contains from two and one-half to four per cent. of carbon.

Silicon stands next in importance to carbon, in respect to its ffect upon the character of the metal. It exerts a controlling influence upon the chilling properties of the iron, since its tendency is to prevent the chemical combination of the carbon and iron. A very small variation in the percentage of silicon produces a prodigious effect in this particular. In a paper read before the chemical section of this institute, in 1883, upon the "Genesis of a Car Wheel," I explained at some length the important bearing which silicon has upon that industry; a brief extract will suffice to indicate its scope: "The most important difference between a car wheel and any ordinary casting is the fact that the 'tread' of the wheel, viz., that part which runs upon the rail, is quite different in character from the 'plate' or main body, though cast from the same metal in one pouring. The tread, or rim, is actually harder than steel, thus enabling it to resist not only the wear upon the steel rail, but the still more destructive grip of the brakes, and its average 'life' is not far from 100,000 miles of service. The process by which the hardening of the tread is produced is called 'chilling' (see illustration, *Fig.* 4), * * * but it must not be supposed that all irons possess this property, for it is a comparatively rare one, and little is known, even among expert iron masters, of the causes which produce it. Very recently some light has been thrown upon the subject by the aid of chemical analysis, and scientific investigation will doubtless reveal still more clearly what is as yet but dimly seen. * * * It has been found, for example, that the substance, silicon, which is always present in pig iron, exerts an extraordinary influence upon its chilling power, and a variation of less than one per cent. of silicon is sufficient to make or mar a car wheel; indeed, it has happened that an entire day's work of several hundred men has been spoiled by an excess of one-half of one per cent. of this substance creeping undetected into the mixture."

The notion has long prevailed (like many other fallacies born of ignorance) that silicon produces "blow-holes" or unsound castings, but such is not the case; on the contrary, its tendency is to produce an exceedingly fluid iron, retaining its heat for a long time, owing, I believe, to the fact, not generally known, that the "specific heat" of iron, rich in silicon, is much higher than a similar grade of metal containing but little of that element. Unfortunately we cannot measure the temperature of molten iron accurately, but I am convinced that pig iron varies in its melting point just as it varies in chemical composition, and that this variation extends through a range of many hundred degrees. It is a modern practice, especially in England, to substitute a small quantity of "silicon pig" in the cupola for the more expensive Scotch irons, in order to obtain soft castings from a mixture of pig iron and scrap. The proportion of silicon in pig iron may vary from three-tenths of one per cent. to three and one-half per cent.

Phosphorus as an element in pig iron tends to render the molten metal very limpid, so that it will take an extremely fine and sharp casting from the most delicate patterns. The famous Berlin castings of reproductions in iron of ancient armor and other ornamental objects, are obtained by using iron rich in phosphorus, but it possesses the disadvantage of rendering the metal brittle and unfit for many practical uses. * * *

The percentage of phosphorus in pig iron may vary from a trace to one and one-half per cent.

Manganese is commonly supposed to exert a hardening tendency upon pig iron, but experience has taught me to regard this as another mistaken notion, it undoubtedly produces a marked effect upon the character of the white crystalline structure. You may readily recognize "a manganese chill" by its coarse lamellar or foliated filaments and by the tendency which it produces to form white iron or "hard spots" in isolated places throughout the gray portion of a casting. Manganiferous pig iron has been used to produce chilled castings, but it does not make a durable wearing surface; the chilled tread of a car wheel, for example, produced by this method, presents to the eye, when broken through the section, a handsome appearance, but the white metal is comparatively soft; it may be easily bored, and, what is more serious, it crumbles readily under the impact of rapid shocks on the rail.

A remarkable effect is produced upon the character of hard iron by adding to the molten metal, a moment before pouring it into a mould, a very small quantity of powdered ferro-manganese, say one pound of ferro-manganese in 600 pounds of iron, and thoroughly diffusing it through the molten mass by stirring with an iron rod.* The result of several hundred carefully conducted experiments which I have made, enables me to say that the transverse strength of the metal is increased from thirty to forty per cent., the shrinkage is decreased about twenty-five per cent., while nearly one-half of the combined carbon is changed into free carbon; the percentage of manganese in the iron is not sensibly increased by this dose, the small proportion of manganese which was added being found in the form of oxide in the scoria. The philosophical explanation of this extraordinary effect is to be found in the fact that the ferro-manganese acts simply as a deoxidizing agent, the manganese seizing any oxygen which has combined with the iron, forming manganic-oxide, which, being lighter than the molten metal, rises to the surface and floats off with the scoria. When a casting which has been artificially softened by this novel treatment is re-melted, the effect of the ferro-manganese disappears and hard iron results as a consequence.*

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*Quite a business is done by one of the members of this association in crushing ferro-manganese for the various car wheel foundries.—ED.

The percentage of manganese in pig iron may vary from a mere trace to two per cent., or even more.

Sulphur is, without doubt, the most deleterious substance found in pig iron. The other elements all produce effects which may be beneficial for certain purposes, but sulphur is an enemy greatly to be dreaded, since it has a strong affinity for iron, combining with it at a low temperature; it is even possible to bore a hole in red-hot iron by means of a stick of sulphur, yet I have actually seen shrinkage holes and cavities in imperfect castings filled with a composition of melted sulphur, the manufacturer failing to appreciate the deleterious effect which this material will produce upon the iron when the worn-out casting comes back to be remelted, and this is but one of many blunders which are committed through ignorance on the part of practical founders.

The presence of sulphur in pig iron is due mainly to bad fuel or to imperfect roasting of the ores containing that element, or to improper fluxing. The proportion of sulphur in pig iron may vary from a mere trace to more than one-half of one per cent.

These various elements all produce sufficiently marked effects upon the fracture and general appearance of pig iron to enable an expert, who carefully studies the matter in connection with the analysis of the iron, to estimate by the eye the approximate composition of any given sample within a surprisingly close margin of error. In the case of silicon, frequent tests have shown that it is possible to predict the percentage of that element within three-tenths ($\frac{3}{10}$) of one per cent. of the actual amount subsequently reported by chemical analysis, and although I have not yet succeeded in estimating with equal success the proportion of the other component elements of pig iron, I believe the method by inspection is susceptible of great development.

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*A few years ago, Mr. William Wilmington, of Toledo, O., patented a process for softening the hubs and plates of car wheels without affecting the chilled tread by sprinkling powdered ferro-manganese into the head box after the mould is partly filled. It is claimed that new wheels are being made in this manner out of old wheels without the use of pig iron. Mr. Wilmington's patents do not cover the process of softening hard iron in the manner described above.

Traces of other elements are also found in pig iron, but these do not appear to exert a very important influence upon the character of the metal, and cannot be considered in detail at this time.

It is difficult to define the line of demarcation between pig iron, steel, and malleable iron, since one blends almost insensibly into the other. The following table represents fairly well the extreme variations in composition of these three forms of iron :

	Pig iron.	*Steel.*	*Malleable Iron.*	
Iron, ...	90 to 95	98.5 to 99.5	99 to 99.5	per cent.
Carbon, ...	2.5 to 4	1.5 to 0.5	0.1 to 0.5	"
Silicon, ...	0.2 to 3.5	Tr. to —	0 to Tr.	"
Sulphur, ...	Tr. to 0.5	Tr. to —	0 to Tr.	"
Phosphorus, . .	Tr. to 1.5	Tr. to —	0 to Tr.	"
Manganese, . .	Tr. to 2	Tr. to 2	0 to Tr.	"

* * * * * * *

We are told that the equipment of railways consumes more than one-half of the world's production of iron, and when we consider that we have more miles of railway in the United States than any other country, or, indeed, the whole of Europe, we can begin to appreciate the magnitude of the needs for the raw material; it is estimated that there are more than *ten million car wheels* required to furnish the rolling stock in this country, these alone consuming more than 2,000,000 tons of iron.

In the manufacture of stoves, ranges, cooking utensils, iron pipe, rolled iron, nails and spikes, fire arms and cutlery, sewing machines, fire proof safes, steam fire engines, pumps, hammers, elevators, planers, saws, axes, general hardware, machinery and all kinds of machine tools, we consume vast quantities of iron, and in most of these products we lead the world both for excellence of workmanship and economy of production.

In the field of artistic cast-iron work we have scarcely made an opening. It is in this direction that I think the greatest opportunity for developing the skill and ingenuity of our young mechanics may be found, and for this reason I have taken the pains to secure specimens of the finest foreign work, and also of our home productions, for inspection.

Explanation of Plates.

Figs. 1 and 2 show eight "chill test" samples, cast from different specimens of gray iron arranged in a graduated series, ranging from one showing no tendency to crystallize as white iron, to one which chills white throughout the sample.

Fig. 3 shows the remarkable crystalline structure of white iron ingots cast from gray metal in iron moulds, the crystals forming at right angles to the chilling surface, reveal a well-defined line of demarcation at points equidistant from the surface.

Fig. 4 shows a broken section of a chilled cast-iron car wheel, cast in a "green sand" mould, provided with an iron ring, or "chill" producing a chilled or hard iron thread, with a soft gray iron hub, plate and arms,

[Acknowledgment is due to Dr. Wahl, Secretary of the Franklin Institute, for his cordial consent to the use of the reproductions accompanying this article.—ED.]

◆

Number of Trees to the Acre when Spaced Uniformly.

Dist. apart.	*No. of Trees.*	*Dist. apart.*	*No. of Trees.*
1½ by 1½ feet,	19,360	7 by 7 feet,	885
2 " 1 "	21,780	8 " 8 "	680
2 " 2 "	10,890	9 " 9 "	532
2½ " 2½ "	6,960	10 " 10 "	437
3 " 1 "	14,520	11 " 11 "	361
3 " 2 "	7,260	12 " 12 "	300
3 " 3 "	4,840	13 " 13 "	257
3½ " 3½ "	3,555	14 " 14 "	222
4 " 1 "	10,890	15 " 15 "	193
4 " 2 "	5,445	16 " 16 "	170
4 " 3 "	3,630	16½ " 16½ "	160
4 " 4 "	2,722	17 " 17 "	150
4½ " 4½ "	2,151	18 " 18 "	134
5 " 1 "	8,712	19 " 19 "	120
5 " 2 "	4,356	20 " 20 "	108
5 " 3 "	2,904	25 " 25 "	69
5 " 4 "	2,178	30 " 30 "	48
5 " 5 "	1,742	33 " 33 "	40
5½ " 5½ "	1,417	40 " 40 "	27
6 " 6 "	1,210	50 " 50 "	17
6½ " 6½ "	1,031		

Refrigeration of Gases From Charcoal Kilns.

By DENNIS CHURCH, *Goodrich, Tenn.*

[Note.—During the second session of the eighth annual meeting of the United States Association of Charcoal Iron Workers, at Nashville, November 16th, 1887, Mr. Church, by request, detailed the investigations which he has since prepared for the JOURNAL.—ED.]

In utilizing the gases and vapors generated in the charring of wood for the manufacture of wood alcohol and acetate of lime, the first step in the process is to condense these gases and vapors into a liquor which is called pyroligneous acid. This condensation is ordinarily accomplished by the refrigerating effect of cold water, and in establishing such a plant, one of the first things to be considered is an abundant supply of water.

During the past summer, at the works of the Calera Furnace and Charcoal Company, Alabama, there was a great scarcity of water and it was with difficulty that the work was kept going. From our inability to get water we were obliged to consider the subject of artificial refrigeration, and in this connection, I made the following calculations, which may be of interest to some of the readers of the JOURNAL:

In charring wood in an oven (kiln) or retort, there is given off about 200 gallons or 1,600 pounds of pyroligneous acid for every cord of wood treated. As a large portion, at least 95 per cent., of pyroligneous acid is water, and as it leaves the kiln or retort in the shape of steam, for the purpose of this calculation, I use the heat equivalent of water as a basis.

A unit of heat is one pound of water heated one degree, F. In the melting of ice at 32° F into water at the same temperature, there is absorbed 143 units of heat, or one pound of ice at 32° F., in melting, would reduce the temperature of 143 pounds of water one degree. In the change of one pound of water at 212° F. into steam, at the same temperature, there is absorbed $964\frac{6}{10}$ units of heat, and in the same change, water being at 32° F., there is absorbed $1{,}144\frac{6}{10}$ heat units. On this basis, one ton of ice in melting to water at 32°, absorbs 286,000 H. U.; and as one pound of water, in the shape of steam, at 212°, in condensing to a liquid at 30°, liberates $1{,}144\frac{6}{10}$ H. U., it follows that one ton of ice will con-

17200 712.50 640

dense 249$\frac{9}{10}$ pounds of water in the shape of steam at 212° into water at 32° F. As one cord of wood in charring generates about 1,600 pounds of liquid in the condition of steam, at a temperature of at least 212° and frequently higher, and as one ton of ice will approximately condense only 250 pounds of liquid from this condition, it will be seen that it will require 6$\frac{4}{10}$ tons of ice to condense the vapors given off from one cord of wood.

The works of the Calera Furnace and Charcoal Co. have 34 kilns, and when run to their full capacity, will charr 100 cords of wood a day. Working up to their capacity (100 cords a day), it would require 640 tons of ice to condense the vapors generated in the charring process.

As a proof of these calculations, the following was observed at the works of the Standard Charcoal Co., at Goodrich, Tenn., in August, 1886. For a period of 12 hours, there flowed from the condensers 20 gallons or 160 pounds of pyroligneous acid per minute. There was 250 gallons or 2,000 pounds of water a minute pumped into the condensers for cooling purposes. The temperature of this water, as it went into the condensers, was 62° F., and as it left them it was 145° F.

There was consequently removed from the condensers each minute 166,000 H. U., or for 12 hours, 119,520,000 H. U. For the condensation of 14,400 gallons pyroligneous acid, there was a refrigerating effect obtained from the water equal to 417½ tons of ice.

While the figures seem at first sight to be large and effectually prohibit the use of an ice machine to replace cold water, in condensing steam to a liquid, there is the additional fact that in any ice machine as yet made all the heat liberated in the formation of the ice has to be removed from the apparatus by the cooling effect of water, and in the practical operation of such a machine a much larger quantity of water is actually used than the resultant ice will subsequently cool.

It is scarcely necessary to say, as a result of these figures, this company decided not to invest in an ice machine.

In connection with the memoranda supplied by Mr. Church, it may be interesting to call attention to the possibilities of removing water from the air supplied to blast furnaces by of means artificial refrigeration. The quantity of water carried into the blast furnace by the air at different seasons has been referred to in the JOURNAL [vide vol. IV, page 301, and vol. VII, page 30], and there would appear to be reason for believing that a partial refrigeration, so that the air would enter the blowing engine at a practically uniform temperature, and consequently uniform degree of saturation, would be practicable. It seems paradoxical to cool the air, and then heat it, but is no more so than the practice followed at some iron works where cold blast is admitted with hot blast, to maintain a practically uniform temperature.

The refrigeration need not extend below, if as far as the freezing point of water, to very materially reduce the quantity of moisture which enters the furnace with the air; and the difference of a few degrees, say a maximum of 50 degrees, will not materially affect the work demanded of the blast heating appliances. This subject is not new to blast furnace managers and the results apparently possible may be overestimated; but it is one which would seem to be worthy of careful attention and possibly of especial research. The admission of excessive moisture through the tuyeres, has a more direct influence on the operation of the blast furnace, than the moisture entering with the stock at the tunnel head, and every manufacturer of pig iron knows how quickly even the latter may affect the working of his furnace; the testimony of many point to changes which are apparently influenced by barometric pressure, or alterations in the dew point of the atmosphere.

While the condensation of moisture from the blast is in no way connected with the refrigeration of gases from kilns, the calculations presented by Dr. Church are to some extent applicable to either case, and hence we considered the present time appropriate for inviting atention to a subject which, at least, seems worthy of investigation.—ED.

THE Treasury Department has instructed custom officers, that imported charcoal iron ends, or the so-called crop ends, cut off from Swedish bar iron in the process of manufacture of the bars, are dutiable at the rate of $22 per ton under the provision for charcoal iron bars. This merchandise has heretofore been classified as scrap iron, dutiable at the rate of $\frac{3}{10}$ of a cent per pound.

Magnetite in Canada.

A remarkable deposit of magnetic iron ore is reported on the north side of Lake Superior. The mine is about thirty miles south-west of the Canadian Pacific railway crossing of the Seine river. about one hundred miles west from Fort William. This deposit is reported to be a high grade Bessemer ore, rising above the surrounding plain to a height of 100 feet, and is in two veins (combined with a parting of diorite), nearly or quite 100 feet wide. The country from the C. P. R. R. main line is level following the valley of Seine river, so that a track can be laid on both sides of the hill, and the ore thrown down and loaded on cars at small cost. It is a black magnetic ore, easy to drill and break; and probably little machinery would be required; no pumping or hoisting.

The following analyses made by the Union Steel Company, Chicago, from sampling by a Marquette Mining Superintendent of recognized ability, show:

SAMPLE.	Metallic iron.	Phosphorus.	Silica.	Titanic acid.	Alumina.	Sulphur.	Lime.
1, ...	63.47	.035	6.60	none	1.09	.22	1.28
2, ...	62.84	.030	7.30	none	1.80	.08	.99
3, ...	63.97	.011	5.89	trace	.98	.04	1.40
4, ...	70.06	.025	2.43	none	.67	.06	
5.	67.95	.005	2.63	none	. . . .	.05	
6, ...	66.92	.012	. . . .	trace	. . . .	trace	

A trace of manganese is also found.

This ore owing, to its high grade and low phosphorus, and the exceptional character of the deposit, should permit of it being quarried down and shipped at a cost which will it is believed yield a handsome profit at Lake Erie and Lake Michigan ports.

The recent increase in the Canadian tariff on iron to $4.00 per ton on pig iron, and $13.00 on bar iron, with anthracite coal on the free list to encourage home manufactures in the Dominion, may open the way to smelt this ore at Fort William.

Increasing the Durability of Timber.

The United States Department of Agriculture (forestry division) has issued a circular of information to wood consumers, from which we clip the following:

DECAY OF WOOD.

1. Decay of wood is due to fermentation of the sap, induced probably by the growth of either bacteria or fungi. These organisms need for their development warmth and moisture, besides the nitrogenous substances and salts contained in solution in the sap.

To *prevent* the growths of these ferments, therefore, the sap in the wood must be dissolved (leeched) or dried out, and moisture be prevented from entering again.

THE MANNER OF USE INFLUENCES DURABILITY OF TIMBER.

2. Timber placed entirely under water or deep in soil (drain pipes) will practically not decay, nor is it liable to rot, when kept absolutely dry, away from the influence of humid atmosphere.

Wood generally decays in proportion to the warmth of the temperature.

Hence on northern exposures, in cool valleys, on high elevations in northern countries, the duration of wood is longer than when placed under opposite influences.

If wood is used in contact with the ground, decay proceeds the more rapidly (beginning at the point of contact with the soil), the looser, moister, and warmer the soil, and especially the greater the liability of change from dry to wet; therefore timber will last longer in heavy, always moist clay, than in loose, alternately moist and dry sand or gravel, or in warm, comparatively dry lime soils.

Ventilation, drying-out, and isolation from moisture will cure dry-rot.

NATURAL FACTORS INFLUENCING DURABILITY.

3. Sound mature trees yield more durable timber than either young or very old trees. Maturity is the time when trees have ceased to grow vigorously, which is indicated by a flattening of

the crown, dying out of branches in the crown, and by change of color of the bark. Maturity may be reached, according to circumstances, by the same species, when the diameter is only a few inches or when it is as many feet. The small tree on arid soil or overtopped by others from its birth, may be as old and older than a tree of greater dimensions growing under more favorable conditions. Of two pieces *of the same kind* the heavier is the more durable, although absolute weight of two different kinds of timber does not determine their relative durability.

Hard-wood, as a rule, can resist deterioration longer than sap-wood, because it contains less sap; but when the sap-wood is well seasoned and heavier this difference disappears.

The site has an influence on durability in so far as it influences the formation of heavy wood.

Quickly-grown hard-woods with wide annual rings, and *slowly-grown conifers* with narrow (yet not too narrow) rings, and "tapped" pines (on the tapped side) yield, as a rule, the most durable wood, other conditions being equal.

Coniferous wood from comparatively poor soils, high altitude, and dense forest, hard woods from rich, deep warm soils and isolated position, are most durable.

The resinous substances in conifers form an element of protection against decay.

4. The following list of trees comprises most of those of common occurrence which have been found to be the most durable. Without means of determining the exact relative value of the different species, it has been possible only to give a series which in general proceeds from the most durable to less durable ones.

EASTERN RANGE—CONIFERS.—Red Cedar, *Juniperus Virginiana L.*; White Cedar, *Chamaecyparis sphœroidea*, Spach.; Arbor-Vitæ, *Thuya occidentalis*, *L.*; Bald Cypress, *Taxodium distichum*, Rich.; Long-leaved Pine, *Pinus palustris*, Miller; Red Pine, *Pinus resinosa*, Ait.; Cuban Pine, *Pinus Cubensis*, Griseb.; Short-leaved Pine, *Pinus mitis*, Michx.

BROAD-LEAVED TREES.—White Oak, *Quercus alba*, L.; Post Oak, *Quercus obtusiloba*, Michx.; Basket Oak, *Quercus Michauxii*, Nutt.; Burr Oak, *Quercus macrocarpa*, Michx.; Chestnut Oak, *Quercus prinus*, L.; Live Oak, *Quercus virens*, Ait., Osage

Orange, *Maclura aurantiaca*, Nutt.; Hardy Catalpa, *Catalpa speciosa*, Warder; Black Locust, *Robinia pseudacacia*, L.; Honey Locust, *Gleditschia triacanthos*, L.; Red Mulberry, *Morus rubra*, L.; Chestnut, *Castanea vulgaris*, var. *Americana*, A. D. C.

ROCKY MOUNTAIN REGION.—Red Cedar, *Juniperus Virginiana*, L.; Pinyon Pine, *Pinus edulis*, Engelm.; Fox-tail Pine, *Pinus Balfouriana*, Murray; Douglas Spruce, *Pseudotsuga Douglasii*, Carr.; Western Larch, *Larix occidentalis*, Nutt.; Burr Oak, *Quercus macrocarpa*, Michx

PACIFIC SLOPE.—Yew, *Taxus brevifolia*, Nutt.; Redwood, *Sequoia sempervirens*, Endlicher; Lawson's Cypress, *Chamaecyparis Lawsoniana*, Parl.; Canoe Cedar, *Thuya gigantea*, Nutt.; Douglas Spruce, *Pseudotsuga Douglasii*, Carr.; Western Larch, *Larix occidentalis*, Nutt.; Live Oak, *Quercus chrysolepis*, Liebm.: Post Oak, *Quercus Garryana*, Dougl.

TIME OF FELLING.

5. With proper after-treatment of the wood the time of felling seems not to affect its durability. Early winter felling (December) should have the preference, because less fermentable sap is then in the trees, and the timber will season with less care, more slowly and more evenly, and before the temperature is warm enough for fermentation to set in.

If the wood is cut "in the sap" it is more liable to fermentation and to the attacks of insects, and more care is necessary in seasoning; for the rapid seasoning, due to the warm, dry atmosphere, produces an outer seasoned coat which envelopes an unseasoned interior liable to decay. When cut in the leaf it is advantageous to let the trees lie full length until the leaves are thoroughly withered (2 or three weeks). before cutting to size. With conifers this is a good practice at any season, and if it can be done, all winter-felled trees should be left lying to leaf out in spring, by which most of the sap is worked out and evaporated.

TREATMENT AFTER FELLING.

6. Always remove the bark from felled timber to aid seasoning —but *not* from the standing tree.

Never allow the log to lie directly on the moist soil

If winter-felled, shape the timber to size within two weeks after felling and leave it placed on blocks—not upon the soil—in the forest, or if shaped at home place in a dry, *airy*—not windy—position away from sun and rain.

If dried too rapidly, wood warps and splits, the cracks collect water and the timber is then easily attacked and destroyed by rot.

With large logs, checking may be prevented by coating the ends with some fatty or oily substance mixed with brick dust, or covering with a piece of linen, cloth, or even paper, or by simply shading them to lessen evaporation; cracks on the sides may be filled in with tow or cotton.

When piling timber place laths or sticks of uniform size at uniform distances under each log, or post, or tie.

Sufficiently thorough seasoning for most purposes is obtained in 12 to 18 months, while for special work, according to the size, from 2 to 10 years is required.

The best method of obtaining proper seasoning, without costly apparatus, in shorter time, is to *immerse the prepared timber in water*, from one to three weeks, to dissolve the fermentable matter nearest the surface. This is best done in running water—if such is not at hand, a bath may be substituted, the water of which needs frequent change. Timber so treated, like raft-timber, will season more quickly and is known to be more durable.

If practicable the application of boiling water or steam is an advantage in leeching out the sap.

COATING TO KEEP OUT MOISTURE.

7. Never apply paint or any other coating to green or unseasoned timber.

If the wood was not well dried or seasoned, the coat will only hasten decay.

Good coatings consist of oily or resinous substances which make a smooth coat, capable of being uniformly applied; they must cover every part, must not crack, and possess a certain amount of plasticity after drying.

Coal-tar, with or without sand or plaster or pitch, especially if mixed with oil of turpentine and applied hot, (thus penetrating more deeply) answers best. A mixture of three parts coal-tar and one part clean unsalted grease, to prevent the tar from drying until it has had time to fill the minute pores, is recommended.

One barrel of coal-tar ($3 to $4 per barrel) will cover 300 posts. Wood-tar is not serviceable because it does not dry.

Oil paints are next in value. Boiled linseed oil or any other drying vegetable—not animal—oils, are used with lead or any other body (like pulverized charcoal) to give substance. Immersion in crude petroleum is also recommended.

Charring of those parts which come into contact with the ground can be considered only as an imperfect preservative, unless a considerable layer of charcoal is formed, and if it is not carefully done the effect is often detrimental, as the process both weakens the timber and produces cracks, thus exposing the interior to ferments.

Cost of Excavating and Handling Rock.

[In ore mining, limestone quarrying, excavation for foundations, grading, etc., the question of cost is always preëminent, and the following data contributed by Mr. Roger Rigly to the Transactions of the Western Pennsylvania Mining Institute are offered for the use of our readers.—ED.]

I. REMOVING EXCAVATIONS BY WHEELBARROW.

A cubic yard of hard rock in place or before being blasted will weigh about 1.8 tons, or 150 lbs. per cu. ft., if sandstone or conglomerate; if good compact granite, gneiss, limestone or marble 168 lbs. per cu. ft. or 2.0 tons per cu. yd. So that we may assume for the case before us that a cubic yard of any of these rocks in place will weigh 1.9 tons or 4,256 lbs. Now, a cubic yard of any of these in the solid, will, when broken up by blasting, for removal by wheelbarrows or carts, increase 0.8 or $\frac{4}{5}$ in bulk, where as average earth, when loosened, increases to but about 1.2 or $1\frac{1}{5}$ of its original bulk, when in place; although after being made into embankment it eventually sinks into less than its original bulk. In estimating for earth, it is assumed that $\frac{1}{14}$ of a cubic yard in place is a fair load for a wheelbarrow. Such a cubic yard will weigh on an average 2,430 lbs. or 1.09 tons. Therefore $\frac{2430}{14}$ or 174 lbs., or 2.31 cu. ft. is the weight of a barrow load. Assuming that a barrow of loose rock should weigh about the same as one of earth, we may take it at $\frac{1}{24}$ of a cubic yard, which equals $\frac{4256}{24}$ or 177 lbs. or 2 cu. ft. of loose rock.

In the following table the second and third columns are prepared on the same principles as for earth. The fourth column is prepared by adding to each amount in the third column $0.002 for each 100 ft. in length of lead, for keeping the wheeling planks in order, and $0.45 per cubic yard, in place, as the actual cost for loosening, including tools, drilling, powder or dynamite, etc., etc., as well as moderate drainage, and every ordinary expense not embraced in the third column; contractor's profit, of course not included.

Ample experience shows that when labor is worth $1.00 per day, the foregoing $0.45 per cubic yard in place, is sufficiently liberal allowance for loosening hard rock, under all ordinary circumstances. In practice, it will generally range between 30 and 60 cents; depending on the position of strata, hardness, toughness, water and other considerations.

Soft shales and other allied rocks may frequently be loosened by pick and plow for from 20 to 30 cents per cubic yard. While on the other hand, shallow cuttings in very tough rock with an unfavorable position of strata, especially in the bottom of the excavation may cost $1.00 or more. These, however, are exceptional cases of comparatively rare occurrence.

The quarrying of average hard rock requires from ¼ lb. to ⅓ lb. of powder per cubic yard in place. But, the nature of the rock, the position of the strata, etc., etc., may increase it to ½ lb. or more. Soft rock frequently requires more powder than hard.

A good churn driller will drill from 8 to 12 ft. in depth, of holes averaging 2½ ft. deep and 2 inches diameter, per day, in average hard rock, at from 12 to 18 cts. per foot. Drillers receive 25 cts. per day higher wages than common laborers.

The annexed tables are computed on the basis of $1.00 per day of ten hours for labor. For labor at $1.25 per day, add 25 per cent. At $1.50 per day, add 50 per cent. For $1.75 per day, add 75 per cent. to table, and so on, increasing or taking from as the case may be.

COST OF HARD ROCK EXCAVATION REMOVED BY WHEELBARROW.

Labor at $1.00 per day of 10 working hours.

Length of lead, or distance rock is wheeled.	Number of cu. yds. in place, wheeled per day by each barrow.	Cost per cu. yd. in place for loading, wheeling and dumping.	Total cost per cu. yd. in place exclusive of contractor's profit.
25 feet, ...	12.2	$0.0864	$0.537
50 feet, ...	10.9	0.0981	0.549
75 feet, ...	9.58	0.110	0.562
100 feet, ...	8.66	0.121	0.573
150 feet, ...	7.26	0.145	0.598
200 feet, ...	6.25	0.168	0.622
250 feet, ...	5.49	0.191	0.646
300 feet, ...	4.89	0.215	0.671
350 feet, ...	4.41	0.238	0.695
400 feet, ...	4.02	0.261	0.719
450 feet, ...	3.69	0.285	0.744
500 feet, ...	3.41	0.308	0.768
600 feet, ...	2.96	0.355	0.817
700 feet, ...	2.62	0.401	0.865
800 feet, ...	2.34	0.448	0.914
900 feet, ...	2.12	0.495	0.963
1,000 feet, ...	1.94	0.541	1.011
1,200 feet, ...	1.65	0.636	1.150
1,400 feet, ...	1.44	0.729	1.207
1,600 feet, ...	1.28	0.822	1.304
1,800 feet, ...	1.15	0.915	1.401

II. REMOVING LOOSE ROCK BY CARTS.

A cart load of rock may be taken at one-fifth of a cu. yd. in place. This will weigh, on an average, 851 pounds, or but 41 pounds more than a cart load of average soil. Since the cart itself will weigh about one-half ton, the total loads in both cases are very nearly equal. The second and third columns of the following table, are prepared on the same principle as for earth. In the fourth column the sums are found by adding to the amounts in the third column, the following items:

Forty five cents per cu. yd. in place for blasting, etc., etc.

Eight cents per cu. yd. in place for loading and two-tenths or one-fifth of a cent for each 100 feet of lead for repairs to road. Contractor's profit not included.

COST OF HARD ROCK EXCAVATION REMOVED BY CARTS.

Labor at $1.00 per day of 10 working hours.

Length of lead or distance the rock is hauled.	Number of cu. yds. in place, hauled per day by each cart.	Cost per cu. yd. in place for hauling and dumping.	Total cost per cu yd. in place, exclusive of profit to contractor.
25 feet,	19.2	$0.065	$0.596
50 feet,	18.5	0.0677	0.599
75 feet,	17.8	0.0703	0.602
100 feet,	17.1	0.0729	0.605
150 feet,	16.0	0.0781	0.611
200 feet,	15.0	0.0833	0.617
300 feet,	13.3	0.0937	0.630
400 feet,	12.0	0.104	0.642
500 feet,	10.9	0.115	0.655
600 feet,	10.0	0.125	0.667
700 feet,	9.23	0.136	0.680
800 feet,	8.57	0.146	0.692
900 feet,	8.00	0.156	0.704
1,000 feet,	7.50	0.167	0.717
1,100 feet,	7.06	0.177	0.729
1,200 feet,	6.67	0.187	0.741
1,300 feet,	6.32	0.198	0.754
1,400 feet,	6.00	0.208	0.766
1,500 feet,	5.71	0.219	0.779
1,600 feet,	5.45	0.229	0.791
1,700 feet,	5.22	0.240	0.804
1,800 feet,	5.00	0.250	0.816
1,900 feet,	4.80	0.260	0.828
2,000 feet,	4.62	0.271	0.841
2,250 feet.	4.21	0.297	0.872
2,500 feet,	3.87	0.323	0.903
3,000 feet,	3.33	0.375	0.965
3,250 feet,	3.12	0.401	0.996
3,500 feet,	2.92	0.428	1.028
3,750 feet,	2.76	0.453	1.058
4,000 feet,	2.61	0.479	1.089
4,250 feet,	2.47	0.506	1.121
4,500 feet,	2.35	0.532	1.152
4,750 feet,	2.24	0.558	1.183
5,000 feet,	2.14	0.584	1.214
1 mile,	2.04	0.612	1.248
1¼ "	1.67	0.750	1.412
1½ "	1.41	0.888	1.576
1¾ "	1.22	1.025	1.740
2 "	1.08	1.163	1.904

A day's work in excavating and filling into carts or wheelbarrows is 11 or 12 cu. yds. of common earth, or 7 to 8 cu. yds. of clay or cemented gravel, at 12 to 14 cents per yard, when wages are $1.00 per day of ten working hours.

THE *Iron Age*, in reply to an inquiry of a correspondent concerning the importations of iron ore and iron from Sweden, says:

According to official documents the imports of iron and steel from Sweden, for the fiscal years ending June 30, 1886 and 1887, were as follows:

	1886.	*1887.*
Pig iron, gross tons,	1,226	556
Iron scrap, gross tons,	101	7,558
Bar iron, net tons,	29,326	28,819
Steel ingots, blooms, slabs and bars, net tons,	3,408	4,622
Wire rods, net tons,	18,522	25,482

No iron ore is imported from Sweden, and the quantity of pig iron is light. How much, if any, crude or manufactured iron and steel originating in Sweden comes to us via England cannot be ascertained, since no statistics are available concerning such transhipment trade in Great Britain.—EDITOR.

◆

WITH the year 1888, our valued contemporary, the *Iron Age*, commenced Vol. XLI, and appeared in a new form, with the reading matter and the advertisements largely separated, and with many features which its readers cannot help but recognize as an improvement. In fact, this valuable newspaper will now appear as a weekly magazine quarto size of about 150 pages, and the reading matter in it will be equal in volume to one of our regular monthly magazines, the more thorough classification of the advertisements which its new form permits will also increase its value as a business directory.

◆

DISCOVERY of manganese ore is reported from Serlano, Italy, which is located right on the coast. The deposit is said to be of considerable extent and depth. In addition to this there is also a large quantity of manganiferous iron ore in the same locality, and as the fuel supply from the neighboring mountains, in the shape of oak wood, is practically inexhaustible, a company has been formed to make ferro-manganese with charcoal.

Blast Furnace Reports.

As constant vigilance is a primary requisite of successful blast furnace management, the importance of full and correct records of the daily, and even hourly operation is becoming more generally recognized. Often a manager may learn much of value for present use from the preserved records of former operation, and the "blast book," "stock book" or "record book," are matters for constant reference.

Many furnace companies prepare elaborately ruled, printed forms, bound or loose, giving full details of the number of charges run, composition of the charge, total quantity of each kind of fuel ore and flux used, and the amount of each consumed in making a ton of iron. The details of cost for fuel, ore, flux, labor, supplies and office expenses; also the quantities of each grade of iron made daily, the temperature, pressure and volume of blast, character of cinder and gas, and often the variations of thermometer and barometer are recorded, as well as remarks upon the furnace operation. We consider a furnace record kept with integrity, a most important feature of blast furnace operation, and have abiding faith in a manager, obtaining good results by keeping his data with exactness and care. It is good policy to share the responsibility of reports among those in charge of the departments, for it offers a medium of making each feel the importance of his work, and encourages him to be more watchful of details. But while a record cannot be too complete, it should not be complex, and in delegating the duty of keeping records they should not embarass those to whom they are committed by unnecessary calculations or repetitions. We have seen furnace reports which cover a large area of paper, but which fail to supply points of information which are important. At one works, whose extent was not very great, the statement was made that it required practically the services of one clerk to work up the daily, weekly monthly and annual reports which were sent to the main office.

Among the features of reports which we think could be abolished, are the calculation of daily costs. This is still attempted at some iron works, but it can give but little satisfaction. An estimate of the cost of manufacture each week is somewhat of a guide, but the labor of figuring out daily cost is wasted. Many of our furnaces still hold to tons, hundred weight, quarters and pounds, in their reports; although sales are made in tons and fractions, in tons and decimals, or in pounds. When the quantity of each ore, fuel and flux, and the output of pig iron is calculated each day, into these measures of weight, a large amount of useless labor is required, and tons and decimals, or pounds would seem to be more satisfactory.

Most report forms start with the number of charges, followed by the composition of the charge, the blanks being appropriately marked. The calculation of the total amounts of each component of a charge each week, or each month are very properly introduced, but we fail to see the necessity of figuring these amounts each day.

At some furnaces the proprietors place a large amount of unessential work on the manager by the multiplicity of ores used. We had occasion lately to examine the reports of a blast furnace covering four years, during which time two blasts were made, and from these we have taken the following figures to indicate the nature of the work placed upon the manager, chemist and the clerical assistant who prepared the reports:

	First blast.	*Second blast.*
Average number of charges run per day, . .	75.5	81.4
Number of ores used in making up the charge:		
Maximum, ...	14	14
Minimum, ...	9	8
Average, ...	12.2.	10.6
Yield of ore mixture in the furnace:		
Maximum, ...	60.32	53.90
Minimum, ...	43.32	41.56
Average, ...	48.61	45.31

From the figures it will be seen that under the most favorable conditions a full barrow of one ore could have been charged but ten times daily, while under other conditions such charge would be made about once in four hours. Hence the ores had to be either filled in very small quantities, and several kinds in a barrow, or the character of the iron produced be subject to great variation. When the distance to be traversed by the fillers is taken into account in handling fourteen different ores, we believe that the cost will show how disadvantageous such practice becomes, even if some of the ores were bought cheaply. It always seems that filling one-thirty-second part of a charge of any one ore indicates either that the particular ore is very bad, or that it is of exceptionally good quality, and the manager is fearful of keeping his iron above a fixed standard. To keep the records of such practice is by no means child's play.

Other features might be mentioned which could be eliminated from the blast furnace reports without interfering with their integrity or decreasing their value, and some suggestions might be offered of other features introduced at individual plants which should be generally adopted, but we hope to take up this subject more in detail and write this to invite suggestions and criticisms. We should be pleased to receive these, as well as samples of reports in use. What is needed is a plain statement of conditions, free from unessentials, but omitting nothing that is important, and the more uniformity there is in such reports the more valuable will they be to those interested in iron manufactures.

Chemical and Physical Properties of Iron Boiler Plate.

A series of laboratory tests undertaken by William H. Morse, M. D., Westfield, N. J., to determine the value and strength of iron boiler plate consisted of observations made upon nine specimens, notated as A, C, E, G, I, K, M, O and R respectively, and which were reputed to the purchasing agent as "of such purity and refinement as are deemed indispensable to consumers." The directions were given "to obtain at least 12 leading qualities." Circumstances rendered nine specimens sufficient. The table shows the tensile strength, reduction of area and relative values of these in each specimen :

Tensile strength. Per square inch.		Reduction of area. Per cent.	Relative values.	
A, .	60,050 pounds, ...	38.0	T2, .	R2.
C, .	56,673 pounds, ...	31.8	T4, .	R6.
E, .	54,320 pounds, ...	33.0	T5, .	R5.
G, .	63,590 pounds, ...	43.7	T1, .	R1.
I, .	50,765 pounds, ...	30.6	T9, .	R7.
K, .	51,130 pounds, ...	29.8	T8, .	R8.
M, .	52,533 pounds, ...	36.5	T7, .	R3.
O, .	58,050 pounds, ...	29.0	T3, .	R9.
R, .	53,107 pounds, ...	34.7	T6, .	R4.

Mr. Morse says: It will be noted that the specimens A, E, G and K are each of the same order of value as regards tensile strength and reduction of area. C and O are more valuable in reduction of area, while I and R have their highest valuation in tensile strength, There is an interpretation to be placed on this. G, A, E and K are valuable in the order named, physically. Now as to the chemical characterization, analyses show as follows:

	Slag.	Nickel.	Cobalt.	Manganese.	Copper.	Carbon.	Silicon.	Phosphorus.
G, ...	0.33	0.01	0.008	0.01	0.009	0.02	0.09	0.07
A, ...	0.44	0.13	0.07	0.02	0.035	0.04	0.11	0.22
E, ...	1.76	0.12	0.02	0.03	0.032	0.05	0.16	0.19
K, ...	1.07	0.03	0.03	0.006	0.04	0.04	0.09	0.09
C, ...	0.72	0.02	0.02	0.03	0.01	0.08	0.14	0.20
O, ...	0.45	0.04	0.02	0.02	0.05	0.06	0.14	0.15
I, ...	. . . .	0.03	0.03	0.02	0.04	0.04	0.15	0.16
R, ...	. . . .	0.042	0.042	0.04	0.006	0.08	0.16	0.19

The best of these irons average, phoshorus, 0.07, while the other extreme is 0.22. The investigations have, however, been made so difficult by the general purity and chemical similarity of the specimens that the effects cannot be independently traced. As for the silicon, I do not regard it as affecting either tenacity or ductility. Good steels are made with as much as 0.20 silicon; but, of course, the fault may be silica instead of silicon. In my tests, however, the slag (which contains the silica) was separately estimated. (Does iron differ from steel in this respect?) The extremes of silicon were 0.09 (G and K) and 0.16 (E and R). Apparently an excess of this element means a decrease of strength. Carbon occurred with beautiful uniformity, the range being only 0.02 to 0.08. William Hackney (1875) showed the amounts of carbon in various well-known steels and irons. Let me quote him:

Crown boiler plate steel, ...	0.22 to 0.24
Fagersta steel, ...	0.08
Swedish iron, ...	0.087
Krupp steel, ...	0.18

Carbon may not measure full fitness, however. Manganese is too low to evidence effects. Copper at highest is only 0.05, and nickel does not exceed 0.13. The range of slag is (seven specimens) 0.33 to 1.76. It is lowest in G, which had 63,590 pounds tenacity, and highest in E, which had 54,320 pounds tenacity. What is the matter, is it slag that weakens, or is it dirt? I cannot answer, unless at a future test I provide some specimens made purposely dirty.

What are the conclusions to be cited to benefit makers and users?

1. The irons were all very much alike in composition, and the effects of carbon and phosphorus are obvious.

2. Phosphorus up to 0.10 per cent. does no harm. Only G and K were below that amount.

3. Strength is varied more by reduction of area than by composition (see the tables).

4. The analyses, made in connection with the physical tests, are indispensable to determine both character and treatment, showing that strength is dependent on reduction.

5. Proofs are made of heterogeneity, and the way of radical improvement may therefore not be other than obvious. Predicating all upon these several conclusions, and noting the facts brought forward, I consider that the best American boiler plate available was that noted G. It has the highest tenacity (63,590 pounds); the highest reduction of area (43.7 per cent.); the least slag (0.33 per cent.); the least phosphorus (0.07 per cent.); the least silicon (0.09 per cent.); the least carbon (0.02 per cent.), and the least nickel (0.01 per cent.), and manganese (0.01 per cent.)

I cannot refrain from adding one more table in opposition of answer to the questions—What have modern processes procured? and, Is English boiler plate superior to American?

The following table shows the physical qualities and chemical value of (1) the G iron above named, (2) the best English boiler plate and (3) the piece of iron found under the obelisk now in Central Park, New York:

	(1)	(2)	(3)
Tenacity,	63,590 ℔.	50,000 to 60,000 ℔.	
Reduction,	43.7 P. C.	Av'ge 37.50 P. C.	
Phosphorus,	0.07 P. C.	0.10 to 0.22 P. C.	0.048 P. C.
Silicon,	0.09 P. C.	0.10 P. C.	0.017 P. C.
Carbon,	0.02 P. C.	0.5 P. C.	0.521 P. C.
Copper,	0.009 P. C.	0.1 P. C.	0.102 P. C.
Manganese,	0.01 P. C.		0.116 P. C.
Cobalt,	0.008 P. C.		0.079 P. C.
Nickel,	0.01 P. C.		
Slag,	0.33 P. C.	0.75 to 1.87 P. C.	0.150 P. C.
Sulphur,			0.009 P. C.
Calcium,			0.218 P. C.
Aluminum,			0.070 P. C.

We may add to the above report that it was made without the knowledge of any of the makers, and that Dr. Morse states that the specimen G, which he pronounces to be superior, was made by Messrs. William McIlvain & Sons, of Reading, Pa., with charcoal hammered blooms.—*Iron Age.*

* * *

Forges and Bloomaries.

THE production of charcoal blooms as reported by the American Iron and Steel Association for 1887, are as follows:

Made from	*Net tons.*
Pig iron and scrap,	28,218
Ore,	15,088
	43,306

as compared with the output of 1886 the metal blooms show an increase of 2,187 net tons and the ore blooms a decrease of 790 net tons.

The number of forges which are prepared to make wrought, iron direct from the ore decreased from 50 in 1886, to 38 in 1887 New York having lost 5, Tennessee 2, and North Carolina 5. In 1886 there were 42 bloomaries prepared to make blooms from scrap iron and pig iron, and in 1887 there were 37. In 1886 the maximum annual capacity of the iron ore forges was 70,000 net tons, and in 1887 it was 63,000 tons. In 1886 the maximum annual capacity of the bloomaries was 65,000 net tons, and in 1887 it was 54,000 tons.

Personal.

In our list of honorary members appears the name of Mr. James C. Bayles, who for two decades has been the editor of our greatest metallurgical paper, the *Iron Age*. In the early history of the United States Association of Charcoal Iron Workers Mr. Bayles gave it his cordial support and did much to advance it by personal effort and by editorial endorsement. In recognition of this and also of his high standing as a journalist, he was elected an honorary member of the Association, and we consider that notice of his retirement from the editorial charge of the *Iron Age* deserves a place on our pages.

We regret that Mr. Bayles has laid down the pen which in the past twenty years did so much to advance the iron and steel interests of the country, but rejoice that such a decision was brought about by his being honored by his selection, independent of politics, to the position of president of the health department of our American metropolis and to his assuming the executive head of the Spiral Weld Tube Company.

In the announcement of Mr. Bayles' retirement on April 1 the statement is made that he is succeeded by his former associate, Mr. Charles Kirchhoff, Jr., and our readers need only run through the back volumes of the JOURNAL to recognize in Mr. Kirchhoff another friend of the Association and its journal.

A change of great importance is thus made with democratic simplicity. Had the publication been less pretentious, the retirement of an editor-in-chief and the promotion of his associate would have been accompanied by considerable parade and possibly a public banquent. But a short business announcement is all that is deemed necessary by the parties interested to publish this transfer of authority.

We can only wish that Mr. Kirchhoff may remain editor of the *Iron Age* as long and note as great advances in it as his predecessor. It is no small sacrifice for a man to give up, neither is it an ordinary compliment for another to be appointed to the position of editor of a great newspaper. With the keen business insight of the publisher, Mr. David Williams, the skill and ability of Mr. Kirchhoff and his associate editor, Mr. George W. Cope, the *Iron Age* will continue to be "our great metallurgical authority." We understand that Mr. Bayles continues his connection with *The Metal Worker*.

Our Iron and Steel Works.

Twenty-five States and one Territory (Washington) now manufacture pig iron in 582 blast furnaces; 433 iron and steel rolling mills are found in 28 States and one Territory (Wyoming); cut nails are made in 15 States; Bessemer steel is made in 35 works (having 74 converters) located in 11 States; Clapp-Griffiths steel in 9 works (having 16 converters) located in 3 States: open-hearth steel in 50 works (having 104 furnaces) located in 11 States; crucible steel in 11 States; and there are iron-ore forges and pig-and-scrap bloomaries in 13 States.

Such is a resumé of the iron and steel works of the United States as given in the Directory published by the American Iron and Steel Association January 1, 1888.

* * *

THROUGH the kindness of Prof. Richard Akerman, honorary member of the Association, we are supplied with the following data concernig the statistics of Sweden for 1886:

	Metric tons.
Iron ores mined,	872,479
Pig iron, all made with charcoal,	442,457
Bar iron and rods made,	237,130
Bessemer iron and steel made,	54,121
Martin iron and steel made,	22,361
Other kinds of steel made,	1,749
Plates made,	13,579
Nails made,	10,289

Number of blast furnaces in operation, 164.
Average production per blast furnace per day, 11.2 metric tons.
Average time per blast furnace in operation, 242.5 days.

Similar statistics for the years 1882, 1883, 1884 and 1885 appear in the JOURNAL, Vol. VII, page 192. The figures for 1886 are in excess of those of other years in the production of Bessemer metal only, and this by but a small amount.

Forest Fires.

The daily press will soon have frequent occasion to chronicle disastrous forest fires in our various States, and while these records are very generally read, it is probable that but few appreciate what a forest fire means.

Our school books picture a sea of flame rushing over a prairie, with buffalo, antelope and horsemen fleeing before it, for owing to the unbroken sweep, the wind drives a prairie fire with great rapidity and consequent intensity. A forest fire is seldom less, and often more to be dreaded than a burning prairie, and at times those who attempt to combat its progress have to run for their lives. Instances are not wanting where persons have been burned to death in forest fires.

The most critical time is in the spring before the green leaves are fairly out on the trees, those which fell in the preceding autumn have been kept damp by the winter snows, but in spring the sun dries these leaves, and the edges curl up into a most inflammable mass. Later in the season when the trees are in leaf and the underbrush green, the fallen leaves retain the moisture longer, and the growing vegetation offers some impediment to the flames. When the dry leaves are unprotected by shade, and a fair breeze is stirring, a forest fire travels with great speed and in a few hours will cover miles of territory, destroying standing timber and stopping the growth of sprouts which in a few years would be trees. A fire sweeping through a growth of sprout ten to fifteen years old, not only kills them and necessitates a new growth starting, but it also often damages those which come up, for by the time the new sprouts, (which are somewhat checked in the growth by the ground being burned over) attain a fair start, the sprouts which were killed rot and fall on them, crushing many into useless contorted shapes.

We are rapidly approaching a time when our forest growth will be of great value to us, and the loss by fire now, will be severely felt in 1900. Every tree, every sprout burned represents a prospective money value.

A large percentage of forest fires are due to criminal carelessness or design. There are, of course, accidental fires arising from locomotive sparks or from some extraneous cause. The hunters are responsible for a number of fires resulting from camp fires not properly extinguished. Bee hunters make fires and burn honey-comb and other aromatics to attract bees so as to follow them and get the honey. Charcoal burners carelessly allow fire to spread from their pits or wagons. The miserable, unaccountable feeling of spite causes parties who have, or think they have, a grievance to fire their supposed enemy's lands, and the peculiar laws of most States which allow cattle to run at large tempt scamps to burn off a neighboring tract to secure free grazing ground from the vegetation which springs up. Fortunately an interest in the laws which impose heavy penalties upon the offenders, and provide for liberal rewards for the detection of those who cause forest fires has of late been taken and good will undoubtedly result from the agitation.

By some of these laws the county commissioners of the several counties are made responsible for a proper surveillance of, and protection to woodlands. This means a great deal to the owners of timbered lands who must assemble a large force of men to beat back, or fire against an advancing forest fire.

Ohio's Iron Ore Production.

STATE Mine Inspector Bancroft's annual report shows that last year's production of iron ore in Ohio exceeded that of 1886 by 32,981 tons. The output by counties (2,268 pounds to the ton), is as follows:

	Black band.	*Hematite.*
Columbiana,		7,800
Gallia,		8,326
Hocking,		9,118
Jackson,		36,362
Lawrence,		147,479
Mahoning,	21,630	
Herry,		27,711
Scioto,		14,784
Tuscarawas,	61,595	
Trumbull,	4,740	
Vinton,		37,920
Totals,	87,965	289,500

Total tons, 377,465.

The Iron Ore Supply.

The year 1887 having shown a larger output of pig iron than any previous year, likewise exhibits a greater production of iron ores than heretofore. We have no means of knowing absolutely the exact amount of iron ore produced in any except census years, for statistics are not collected annually from all mines; however, it is possible to form a close approximation by multiplying the number of tons of pig iron made by the average quantity of ore used per ton of iron and adding to this an estimate of the ore used as "fix" in rolling mills, or for the manufacture of blooms, or for fluxing silver ores, grinding paints, etc. Then from this total is to be deducted the foreign ores imported and the rolling-mill cinder used in blast furnaces. A calculation made in this manner indicates that our total consumption of iron ores in 1887 exceeded 13,000,000 tons, from which should be deducted about one and one-half million tons for foreign ore and mill cinder to obtain the apparent consumption of domestic ores. If now to this is added the increased stocks which existed at the close of the year over those which were on hand at the beginning of the year, we find that our domestic iron-ore mines produced over 12,000,000 tons in 1887. To appreciate what this amount of ore means, we may state that if the iron ore was loaded on to trains of cars (15 tons to a car), standing close together, they would occupy a length of railroad track equal to twice the distance from New York to San Francisco.

It is interesting to note the localities from which our supply of ores was obtained, the Lake Superior region, of course, standing at the head with a considerable interval between it and any other. The total amount of ore produced by the four districts comprising the Lake Superior region in 1887 was 4,657,652 gross tons, an increase of over 1,000,000 tons from the figures of 1886, and crediting that interesting section of the country with an output to date of nearly 36,000,000 gross tons. The output of the Lake Superior mines in 1887 represented nearly 37 per cent. of our total ore production, and the yield of the ores was such that they produced nearly 45 per cent. of the pig iron made in 1887. Of the four districts which comprise the Lake Superior region, the Marquette district ranks first with an output for the last year of 1,836,953 gross tons, and although the production was never as great, the difference between the figures for 1887 and 1882 is but 7,569 gross tons.

The largest individual producer in the Marquette district was the Lake Superior mine, which is credited for 1887 with 302,909 gross tons. The Republic mine follows next with 220,624, and the Cleveland next with 207,441 gross tons.

The Gogebic and Menominee ranges had a close race as to output, the figures for 1887 being:

	Gross tons.
Product of the Gogebic range, ...	1,237,704
Product of the Menominee range, ...	1,198,743

The big mines of the Gogebic range produced in 1887 the following amounts:

	Gross tons.
Colby mine, ...	258,518
Norrie mine, ...	217,254
Ashland mine, ...	175,561
Aurora mine, ...	159,252

While the prominent shippers of the Menominee range were:

	Gross tons.
Chapin mine, ...	334,028
Vulcan mine, ...	205,036
Ludington mine, ...	101,653

The mines of the Minnesota Iron Company, in the vicinity of Lake Vermilion, Minnesota, produced 394,252 gross tons.

Next to the Lake Superior district, Pennsylvania and New York would probably rank second and third as producers, but owing to the large number of mines in each State, and the variety of ores produced it is impossible to arrive at exact figures, and as so much of the foreign and Lake Superior ores are introduced into these States, it is impossible to form a close estimate from the pig iron production. The output of magnetites in New York and Pennsylvania in 1887 was over a million and a half gross tons, which amount was nearly equally divided between the two States, the Lake Champlain district supplying the bulk of the New York magnetites, while the Cornwall ore hills, Pennsylvania, stands at the head of individual producers with an output of 667,210 gross tons. The magnetic iron mines of New Jersey report a product for 1887 of 547,889 gross tons.

The importation of foreign ores bears a more important relation to our iron ore supply than is generally appreciated. We find that in 1887 we received from foreign countries 1,194.301 gross tons of iron ore, representing about 9.5 per cent. of our total iron ore consumption, and producing about 10.5 per cent. of all the pig iron we made. Surely the duty of 75 cents per ton placed upon foreign ores cannot be considered as excessive in the face of the fact, that one ton of pig iron in every ten manufactured in this country is produced from oresextracted from foreign mines. If this duty were decreased, the importations of ore would probably be augmented, but the encouragement to ship into this country only the best ores would be removed.

The output of the mines in Alabama, Tennessee, Missouri, Virginia and Ohio ranged approximately from 6 per cent. in the former to 3 per cent. in the latter of the total consumption. Fully 4 per cent. of the iron ore (?) used in the blast furnaces of the country is cinder resulting from the operation of rolling mills.

The tendency is decidedly towards the use of richer ore mixtures in blast furnaces, and the higher class of ores are being carried great distances, the Lake Superior and foreign ores meeting nearly midway between the Atlantic ocean and the Lakes. Renewed interest has been awakened in ore concentration so that the leaner ores may be enriched and stand shipment to more distant points. In cases where this concentration requires the cominution of the ore objection is raised to its finely divided state, but modern furnace practice is rapidly overcoming this trouble, and as ultimately all the ore placed in the blast furnaces is reduced to iron-sand during the smelting process, we question whether the finely divided ores will not grow in demand as furnace managers become more conversant in handling them.

Volume VII.

This issue of the JOURNAL completes Volume VII, the various numbers covering a longer interval of time than any other volume. An index similar to the one which accompanied the previous volumes of the JOURNAL will be supplied to each subscriber, so that those who desire can have the volume bound. The Association still has copies of the various issues of the JOURNAL, which will be sold to persons desiring to complete the seven volumes, at the prices quoted in our advertising pages.

Our National Danger.

We hear considerable comment upon the rapidity with which we as Americans are losing our distinctive nationality, and it would appear as if the lessons of the last few months should encourage us to hold more tenaceously to our characteristics.

We have opened our doors to the oppressed of all other lands. and our generosity has been abused until our boasted liberty is in danger of being confounded with license. One nationality complains of our Puritanical Sabbath observance as restricting their liberties, forgetful of the fact that in their native land they had license to do as they pleased in this respect, but still sought this country as a home because of oppression. Another nationality is angered because a local flag (which is not even the emblem of an existing power) was not displayed from the public building in a city where the elective officers happened to be largely of that nationality. Other instances could be mentioned or concessions noted which are made to certain classes by political platforms or by legislation.

In the coming Presidential conventions planks will be inserted in the platforms of both great parties to catch the Irish-American, the German-American, the Scandinavian or the labor vote, with a corresponding elevation of the self-conceit of the class thus pampered.

It is time for such nonsense to be frowned down. When a man comes from Germany, Ireland, Sweden or Poland and is naturalized he becomes an *American*, not a German American, Irish-American, Polish-American, &c., and by his oath he swears to sustain American institutions, to abide by our Constitution and endorse the principles of our Declaration of Independence. But too often this naturalization is unmeaning. Instead of sustaining our institutions, the effort is made to supplant them by the obnoxious ones of Continental Europe. Our freedom of speech is not objected to, provided the speech is not contrary to the wishes of some secret organization. Our liberty is considered very proper until an employer wishes to operate in his own way, a works in which his capital is invested or until we elect to patronize a railroad company which refuses to be dictated to by its employés. Strikes, boycotts, lock-outs and combines are un-American, and no man who in his heart believes that all men are created free and equal with certain inalienable rights can be in harmony with them. The spectacle of a mine suspending and the works becoming flooded, or a furnace blown out, or of a mill idle with plenty of orders, or travel and transmission of freight interrupted on a railway because *some* of the employés are dissatisfied is un-American. We say *some* because we believe that in a large percentage of cases the minority control the majority, on account of determination and zeal, and it is the few who want to strike who intimidate the rest. Where there are a few zealous, determined men who fearlessly oppose a strike it never materializes.

The JOURNAL is not a political publication, nor is it given to discussing subjects outside of the theory and practice of iron manufacture, but its readers are men who control or operate important industries, and it seems but proper that as their exponent the JOURNAL should not be silent upon a question which affects so many interests of its readers. The JOURNAL is an American publication and believes in discussing all questions from an American standpoint. It condemns as un-American strikes and boycotts on the part of employés as well as combinations on the part of employers. It believes that every American citizen should be such *de facto* and not merely *de jure*. It believes in American industries and in the government giving them ample protection against foreign productions We have no sympathy with any combination or conspiracy to force labor or materials above their intrinsic value, but in a country of such vast proportions and varied industries we should help each other, and by a well-digested system of national protection build up and improve each section by utilizing its products in another. Our greatest danger is that anarchy may grow from strikes and boycotts or oligarchy follow as the natural sequence of combinations and trusts.

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THE number of newspapers and periodicals published in the United States is now in excess of sixteen thousand, and increasing at the rate of five per cent. annually. Surely Americans are not at a loss for "something to read."

THE *Iron Age* gives the status of the charcoal furnaces as follows:

Charcoal furnaces in blast April 1, 1888:

LOCATION OF FURNACES.	Total number of furnaces.	Number in blast.	Capacity per week.	Number out of blast.	Capacity per week.
New England,	14	6	520	8	560
New York,	10	4	577	6	490
Pennsylvania,	23	3	210	20	840
Maryland,	13	2	182	11	750
Virginia,	23	0	0	23	1,006
West Virginia,	3	0	0	3	165
Ohio,	18	4	260	14	1,060
Kentucky,	2	1	130	1	85
North Carolina,	2	1	92	1	80
Tennessee,	9	3	910	6	1,170
Georgia,	2	0	0	2	114
Alabama,	10	8	1,540	2	380
Michigan,	25	12	3,232	13	2,503
Minnesota,	1	0	0	1	220
Missouri,	4	2	563	2	440
Wisconsin,	11	4	1,060	7	920
Texas,	2	1	178	1	100
California,	1	0	0	1	245
Washington Territory,	1	1	175	0	0
Oregon,	1	0	0	1	125
Total,	175	52	9,629	123	11,253

* * *

ANALYSES of charcoal foundry pig irons made from Lake Superior ores at Detroit, are reported by Mr. H. S. Fleming as:

	Silicon.	Phosphorus.	Sulphur.	Manganese.	Iron.
No. 2 foundry,	1.570	0.240	0.041	. . . .	94.283
No. 3 foundry,	0.800	0.144	0.056	. . . .	94.688
White,	0.186	0.263	. . . .	0.092	. . . .

Roll of the United States Association of Charcoal Iron Workers.

[Corrected to May 1, 1888.]

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JOURNAL

OF THE

UNITED STATES ASSOCIATION

OF

Charcoal Iron Workers.

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The JOURNAL OF THE UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS which for eight years has been published by the organization of which it has been the exponent, has been so well received in the limited circle of those specially interested in the production and manufacture of charcoal iron, that in deference to a wish often expressed by others, it has been decided to broaden its scope. Commencing with the present number the JOURNAL passes under the control of a number of gentlemen interested in mining and smelting iron ores, and manufacturing iron and steel, who are willing to risk capital in the endeavor to establish an American periodical specially devoted to iron metallurgy. The JOURNAL will continue to represent the United States Association of Charcoal Iron Workers and for the present no change of name will be made, for it is deemed expedient to retain the influence which the JOURNAL already has, and have the publication win its way to more popular favor by its contents.

The plan is to issue the JOURNAL bi-monthly and those who have contributed to its capital are willing to sink their investment if it be necessary, but it is confidently believed that there is sufficient demand for such a periodical to at least make it self-sustaining. An earnest and honest effort will be made to so conduct the JOURNAL as to fill the place which is believed to exist for a magazine treating of iron ores, and iron and steel production, and manufacture.

The JOURNAL does not enter the list as a rival of any American publication but will in part be modelled after some of the European periodicals which have earned enviable reputations as authorities. It will not be a competitor for current news, nor strive for the first publication of papers read before technical societies, on the contrary it is expected that much of its contents will be condensed from the columns of the admirable list of trade and technical newspapers, both home and foreign, and it is our desire to offer our contemporaries matter worthy of reproduction in publications devoted to kindred topics. We also expect to furnish valuable information by résumés taken from the transactions of engineering and other societies.

The details to be treated will be developed according to the favor with which the JOURNAL is received, but several features have been decided upon which may be enumerated.

Iron ores and mining will be a specialty of the JOURNAL, arrangements having been made for detailed descriptions, with illustrations, of some of our most important iron mines. The methods of mining, machinery employed, analyses of ores, etc. will command attention.

The various methods of treating and concentrating iron ores, viz: washing, roasting, jigging and magnetic separation, will be discussed, and the appliances for crushing, roasting, washing or separating illustrated.

A series of replies to queries pertinent to the management of mines, blast furnaces and iron manufacturing industries, prepared by those eminently fitted to give information will be published.

Comparative records of blast furnace and mill practice, will also be presented and an attempt made to place figure which are of special interest to those engaged in pig iron production in such position as to be readily referred to.

If the experiment proves successful, as we believe it will, and the publication is well sustained, we will strive to make it worthy of all the influence it commands.

Iron Ore Concentration No. 1.

Concentrating or beneficiating ores has been mainly confined to those of copper, silver and gold, etc., and but little attention has been given in this country to enriching iron ores for the blast furnaces, except by roasting or washing, both of which processes have been liberally treated in earlier volumes of the JOURNAL. For the purposes of eliminating sulphur, carbonic acid, or water, or for making an ore more friable, roasting answers a very good purpose; similarly washing removes much ochreous clay, gravel and sand from brown hematites, enriching them sufficiently to make them available for smelting purposes. But there are many ores which require a different treatment and for years the leaner magnetites obtained in the Lake Champlain district, have been separated (generally after a preliminary roasting and crushing under stamps) by means of tray jigs.

Several works which have been erected to separate ores on a large scale and have proven failures, had a tendency to discourage further efforts and there are to-day but few active separating works operating on iron ores. The lean magnetites which are necessarily mined with the richer ore, and some of the easily mined but lean magnetites offer the most encouragement for separation, and it is not surprising that a realization of the possibilities in this direction, aided by the urgency of those interested in the introduction of apparatus and machinery applicable to the purpose, should have again brought the concentration of iron ores into prominence. It will be within the province of the JOURNAL to present information upon the methods employed and the results obtained, and we shall endeavor to give our readers information concerning approved appliances for reducing and sizing the ore so as to be properly treated, and also to post them as to the special features of various jigs or separators. Having devoted considerable attention to the subject of wet concentration by means of jigs and of dry concentration by magnetism, and having visited all of the plants of note where iron ore is concentrated by jigs, or inspected the operation of various magnetic separators, we will be in condition to present to our readers the details which to them will be most useful.

The initial contribution on this subject will treat of wet concentration, and our first description of a plant will be of the new separator of the Chateaugay Ore and Iron Company at Lyon Mountain, New York,* where magnetic iron ore yielding less than 40 per cent. of iron is crushed dry by jaw crushers, screened and then concentrated wet in revolving jigs, which have also a vertical jarring motion. The object of the jigs is to separate by gravity the iron ore which is heavy, from the lighter particles composing its gangue and have these lighter particles carried away by water.

CONCENTRATING WORKS OF THE CHATEAUGAY ORE AND IRON COMPANY.

At the noted Chateaugay mines at Lyon Mountain, New York, in the heart of the Adirondack mountains, thirty miles west of Plattsburgh, there are three works for separating iron ore, one is an old style plant consisting of a set of stamps to reduce the ore to suitable size, and tray jigs for separating it. In the others jaw crushers reduce the ore, and rotating jigs separate it. We lately visited these plants but will confine the description to the new works, erected in 1886, copying liberally from papers (which will appear in Vol. XVII, Transactions of the American Institute of Mining Engineers,) by Mr. Theodore A. Blake, upon "The Blake System of Fine Crushing," and by Mr. Fred. S. Ruttman upon "Concentrating Magnetite with the Conkling Jig at Lyon Mountain, New York.

Mr. Blake thus describes the new concentrating works at Lyon Mountain:

*** A general description of one of the separating works at the Iron Mountain, Mo., also appears in this number.—ED.**

PLATE 1.

SIDE ELEVATION OF THE

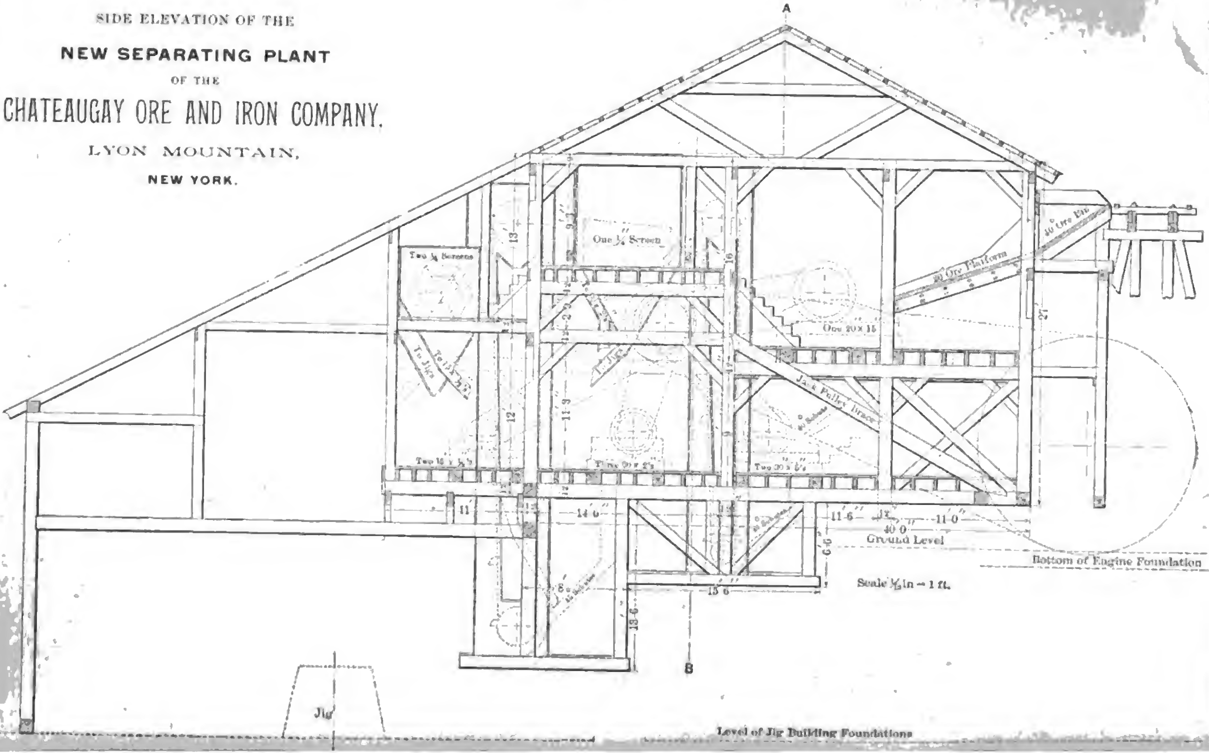
NEW SEPARATING PLANT

OF THE

CHATEAUGAY ORE AND IRON COMPANY.

LYON MOUNTAIN,

NEW YORK.



"This is a complete crushing and concentrating plant, with a daily capacity of 600 long tons, the crushing being done entirely by Blake crushers, and from fifteen inches down to ¼ of an inch; it was built in accordance with plans shown in plates 1 and 2. The deposit or vein of magnetic iron-ore is enormous, and the output from this mine often exceeds 1,500 tons daily. The richer portions are sorted out and shipped, the leaner ores, consisting of magnetic iron-ore in grains, disseminated through a tough quartzose and feldspathic gangue, are sent to the mills for concentration. In order to effect this by jigging, with best results, it must be reduced to a size to pass a ¼-inch or 5/16-inch round hole. The jigs used are those known as the Conkling, with an annular revolving sieve and central discharge. The concentrates pass into a hutch from whence they are taken out by belt elevators. The capacity of one of the jigs, as run at Chateaugay, is 100 tons of crude ore in twenty hours, or 5 tons per hour. The elevation and plans of this mill, in accompanying plates 1 and 2, show clearly its construction. The ore is brought to the mill by rail, in side dumping cars, carrying on the average 7½ to 8 long tons each, from the various dumps one-quarter to one-half of a mile distant. The mill consists of two groups or systems of crushers, with elevating and screening appliances, each group being an exact duplicate of the other; a "jack-pulley" on main-line shafting being placed centrally between them. Power is derived from a 250 horse-power Harris-Corliss engine, and a battery of three 100 horse-power boilers.

Each group consists of the following crushers, all of Challenge pattern, one 20 x 15, crushing from 15 inches to 2 or 2½ inches. Product of each 20 by 15 is divided, going to two 30 by 5 crushers.

Product of 30 by 5s is elevated and screened; that passing a ¼-inch round hole is finished product, as far as crushing is concerned and is carried to the jigs. The "coarse," 1½ to ¼ inch, goes to three 60 by 2 multiple crushers, each with three jaw openings 20 by 2 inches. Product of these is elevated in No. 2 elevator and screened, formerly through holes ¼ of an inch in diameter, now through 5/16-holes. That passing through the 5/16-screen-holes goes to jigs; that going through 11/16-inch holes goes to two 15 by ½ fine crushers. Each of the 15 by ½ crushers has 7 jaws with openings each 15 by ½ inch. Material not passing

$\frac{11}{16}$-inch holes, but going out the end of screen, goes back to the 60 by 2 multiple crushers. Product of 15 by $\frac{1}{2}$ fine crushers is elevated and screened; material not passing $\frac{5}{16}$ holes returning to them. Each group of crushers has three Conkling jigs."

As the plant consists of two such groups described by Mr. Blake, the total equipment may be summarized as:

Three 100 H. P. boilers, One 250 steam engine.
Two 20" x 15" crushers, Four 30" x 5" crushers.
Six 60" x 2" multiple jaw crushers (3 jaws).
Four 15" x $\frac{1}{2}$" multiple jaw crushers (7 jaws).
Revolving screens and elevators.
Six Conkling jigs.

The following description of the jig used and the illustrations of it, plates 3 and 4, are taken from Mr. Ruttman's paper.

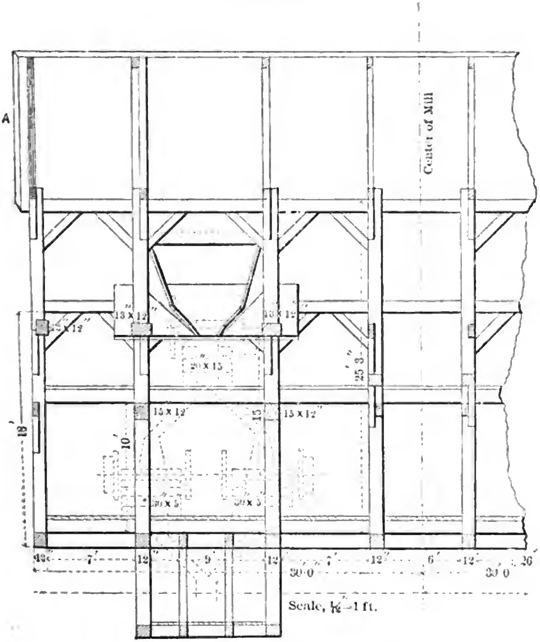
"The machine, as shown in the accompanying drawings, may be divided into four essential parts, viz: the frame; the tub; the jig; the elevators. For the better understanding of the drawings, the following index of the names of the parts is appended, the numbers referring to corresponding numbers in plates 3 and 4.

INDEX.

1. **Bevel-wheel.**
2. **Pinion.**
3. **Upright shaft.**
4. **Shoe.**
5. **Link.**
6. **Upper collar.**
7. **Trunnion-piece.**
8. **Lower collar.**
9. **Outside nut.**
10. **Flange.**
11. **Inside nut.**
12. **Standard.**
14. **Hoop.**
16. **Screen-plates.**
18. **Spider.**
19. **Key.**
20. **Cone.**
21. **Water-sleeve.**
22. **Water-box.**
23. **Lower elevator-box.**
24. **Lower elevator-shaft.**
25. **Band-arms.**
26. **Cam-wheel.**
27. **36-inch pulley.**
28. **Pinon-shaft.**
29. **Cone pulleys.**
30. **Lever-beam.**
31. **Yokes.**
32. **Lever-shaft.**
33. **Driving-shaft.**
34. **Top elevator-shaft.**
35. **24-inch pulleys.**
36. **Flange-pulleys.**
37. **Cone-pulleys.**
38. **Spring-pole.**
39. **Strap.**
40. **Bumper.**
41. **3-inch water-pipe.**
42. **Regulating-valve.**
43. **Outlet-pipe to tail-race**
44. **Tub.**
45. **Splash-rim.**

The Frame.—The frame is made of squared spruce or hemlock

PLATE 2.



Cross Section on Line A B (Plate 1).

timber, and cross braced at the sides and ends. The upper string-pieces project beyond the first pair of uprights. The sills are 13 feet 8½ inches long and project beyond the front and rear uprights The frame is 4 feet 1 inch wide inside. To the lower side of the rear cross-piece is attached the bumper for the lever-beam. The main driving-shaft is placed directly over the rear uprights: and 9 inches from the forward end of the string-pieces is placed the shaft for the elevator-pulleys. Between the first and second cross-pieces is a cross-beam which carries the journal for the upright or jig-shaft. From this timber to the forward cross-piece extend two timbers, which carry the boxes for the pinion shaft. To the second and rear cross-pieces are bolted pieces 2 feet high, which carry the spring-pole. On the front of the second pair of uprights below the string-piece, are the journals which carry the lever-shaft. The whole is framed with mortise and tenon-joints, and tied together with 1 inch bolts.

The Tub.—The tub is made of yellow pine 4 feet 11 inches, inside diameter. The staves are 4 feet 8 inches high, 5 inches wide and 2 inches thick, rabeted 1 inch deep, 3 inches from the lower edge to receive the bottom. The staves are not doweled. A door in the side having beveled edges gives access to the interior. Four iron bands provided with tighteners bind the whole together. A hole near the bottom fitted with a plug serves to empty the tub for the purpose of examination or repairs. Two troughs to allow for the passage of the elevator belt and buckets into the tub are let into the front.

The Jig.—The jig consists essentially of a circular sieve, suspended from one end of a lever, being moved up and down by a cam striking the opposite end of the lever. The concentrates pass through the sieve to the bottom of the tub; the tails pass out by means of an annular opening around the jig shaft.

The spider is made in one piece of cast-iron, with a taper bore to receive the jig-shaft which is keyed into it. It is also supported by the standards from the flange, which may be moved by the upper and lower nuts. A sheet-iron hoop, 12 inches high is bent around the spider, and fastened by the holding-down bands which are riveted to the rim, pass through the holes in the end of the arms, and are fastened below with nuts. The screen-plates rest on the arms of the spider and are held in place by U-bolts passing under the arms and through the holes in the screens. The screen-plates are $\frac{1}{2}$ inch thick, made of cast-iron, in segments of $\frac{1}{8}$ of a circle; the holes are $\frac{5}{16}$-inch in diameter on top and $\frac{7}{16}$-inch below.

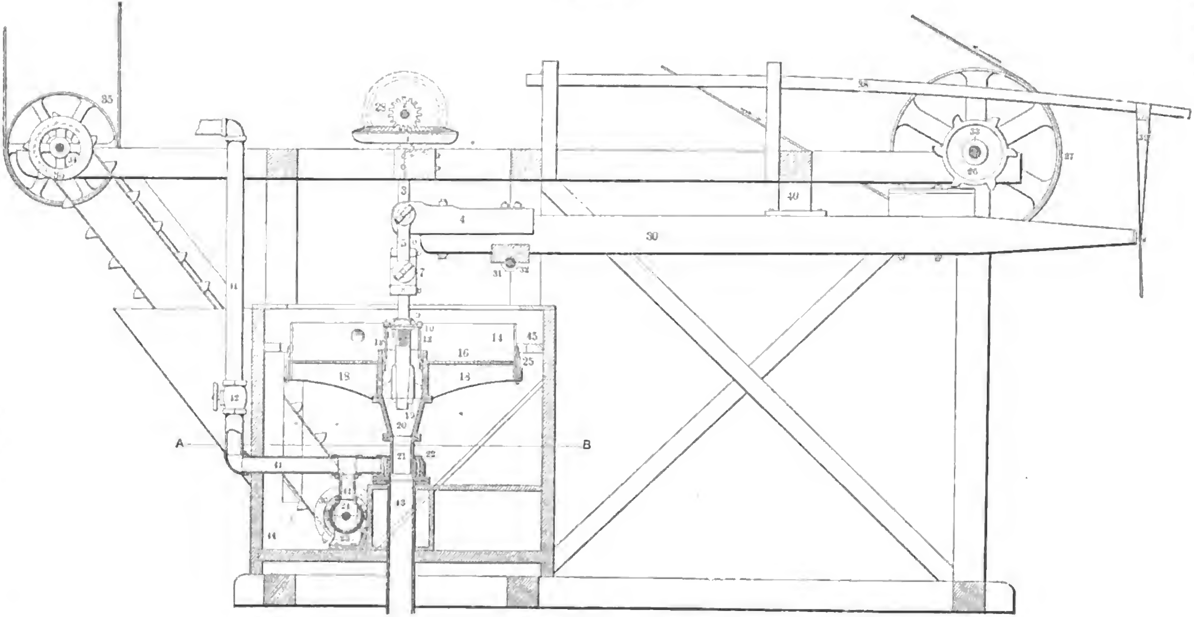
Beneath and bolted to the spider is the Cone (Fig. 20), under that is the water-sleeve (Fig. 21), which slides up and down in the water-box (Fig. 22). All the water which is to be used in jigging passes through these two boxes, and flowing out through the annular openings, keeps the bearings free from grit. Previous to the introduction of these improvements, the water-sleeve would wear out in a very short time. The water under pressure of 8 feet head, enters through the 3-inch pipe (Fig. 41) provided with a valve (Fig. 42) to regulate the quantity.

The jig is suspended in the tub from the end of the lever-beam (Fig. 30). The trunnion-piece (Figs. 11 and 7), is kept in place by the upper and lower collars which are provided with set screws. The links (Fig. 5), connect the jig with the lever-beam. The jig-shaft (Fig. 8) passes up through the horizontal bevel-gear wheel by which it is rotated; the shaft moves freely up and down, but is provided with splines in which fit keys attached to the gear-wheel. The pinion is driven by belt from the rear driving-shaft (Fig. 33). The pulleys to transmit the rotary motion are conical, reversed in order to change the speed. The cam wheel (Fig. 26) is provided with six cams, and is keyed to the shaft which is driven by a belt 8-inches wide, passing over the 36-inch driving pulley (Fig. 27). The cam-wheel makes 43 revolutions per minute, giving about 260 jars per minute to the jig. The lever-beam is set to move the jig up and down about $\frac{3}{8}$-inch, giving a slow up and a quick down-motion. The jig makes seven revolutions per minute.

The Elevators.—The lower elevator-box is provided inside with wooden bearings. The box is bolted firmly to the bottom of the tub. The elevator-pulleys overhang somewhat, to give free exit to the water which passes through the box, the elevator belt is rubber, 4 inches wide and the buckets are riveted to it. The elevators travel at a speed of 10 feet per minute.

The Jigging.—The crushed ore is brought from the hoppers to the jigs by chutes provided with gates at the lower end, just above the screen plates. The screens are first covered closely with pieces of heavy ore about the size of hickory-nuts; the crushed ore is

PLATE 3.



Conkling Jig Section.

then spread over this until it is level with the collar of the spider, about 2½ to 3 inches deep. The spring-pole is connected with the lever-beam by the strap, the water turned on, and the jig started. The water flows upward through the screen-plates and over the collar of the spider, carrying the gangue to the tail-race; the ore settles through the screen, is collected at the bottom of the tub, and thence raised by the elevators to bins. The rotation of the jig produces an equal distribution of the crushed ore on the screen-plates, and also forces the particles to traverse a path longer than the radius of the sieve. The crushed ore is allowed to fall on the screen as near the outer periphery as possible.

The jig has a capacity of treating 5 tons of ore per hour, requiring 135 gallons of water per minute, or 1,620 gallons per ton treated. One man attends to two jigs, his duty being to see that the jig is properly supplied with material to secure a uniform depth on the screen; that the water is flowing in the proper quantity (a depth of ¼ to ⅜ of an inch over the collar being sufficient), and that the concentrates are free from gangue. If there is too much gangue in the product the attendant lets out a hole in the strap from the spring-pole to the lever-beam, to make the shock less violent.

An examination of the bed on the screens during the process of jigging showed the ore lying just above the screen, the greatest depth and largest pieces being near the edge of the screen, gradually thinning out and becoming finer toward the center of the jig, the gangue increasing in depth toward the central point of discharge.

An analysis of samples, taken on October 10th, 1887, gave the following results, the samples being analyzed for iron only:

	Metallic Iron. Per Cent.
"Stock," or material treated,	**43.56**
Concentrates,	**66.90**
Tailings,	**22.91**

which shows a saving of only 47.4 per cent. of the iron contained in the stock.

The chief impurity contained in the concentrates appears to be silica in fine grains. An examination of the tailings shows the lost ore principally in two forms: very fine ore or "slimes;" and small particles of ore imbedded in the larger pieces of gangue.

There seems to be considerable room for improvement in the arrangement of the jig; it occupies a space 10 x 24 feet (allowing 2 feet of working space around the frame). This could easily be reduced to 10 x 10 feet by doing away with the lever, spring-pole, etc., and giving the motion to the jig-shaft by means of a cam working on a horizontal shaft just back of the jig-shaft. The spring-pole could be replaced by a coil-spring on the vertical shaft, with an adjustible nut to regulate the jar. A suitable bumper could be arranged either above or below the bevelled gear wheel. The action of such an arrangement would be similar to that now produced, with the advantage of economy of space and material."

Concerning the results obtained at the separating works of the Chateaugay Ore and Iron Co., Messrs. Maynard and Kunhardt, give the following analyses.*

	Metallic Iron.	*Phosphorus.*
Crude ore contained,	**35.**	**0.025**
Concentrates, contained,	**65.5**	**0.015**
Tailings, contained,	**18 to 22**	**0.033**

At the time of our visit 350 tons of ore yielding 35 per cent. of iron were crushed, and 110 tons of concentrates carrying say 66 per cent. of iron were produced. There were therefore delivered to the works

350 tons × 0.35,	**122.5 tons of Iron.**
The Concentrates showed	
110 tons × 0.66,	**72.6 " " "**
Leaving as loss,	**49.9 " " "**

Then 49.9 ÷ (350—110) or $\frac{94.9}{240}$ = 20.8 per cent. loss in tailing.

According to Mr. Blake, the mill was completed and started September 26th, 1886, and was run in a desultory sort of way until the organization of day and night-shifts, October 18th following, when its operations may be said to have commenced.

The actual amount crushed from September 26th, 1886, to January 1st, 1888, was 122,814 long tons or 137,551 short tons, at a cost for crushing and concentration of $42,200.55, or 34.36 cents per long ton of crude ore or 30.67 cents per short ton, distributed as follows:

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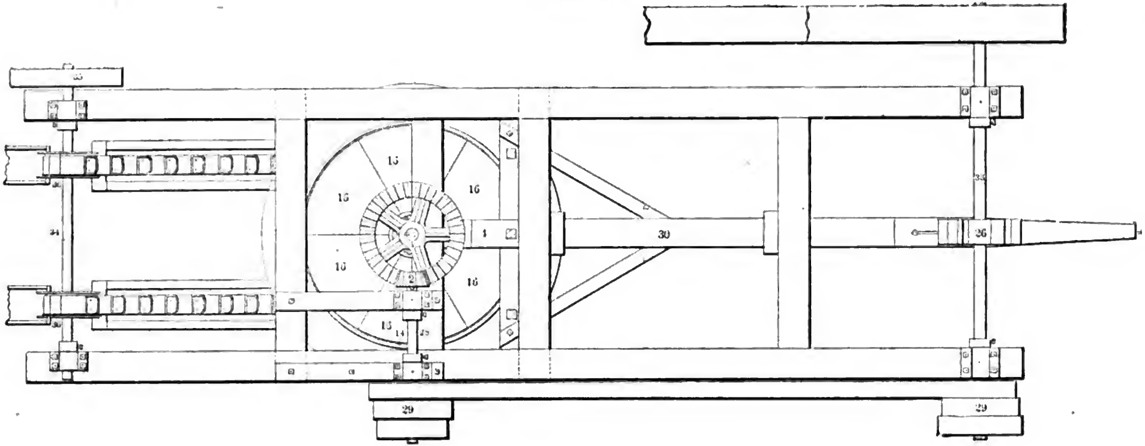
* *Vide* School of Mines Quarterly, Vol. IX, No. 2.

PLATE 4.



Plan of Conkling Jig.

$2{,}018\frac{1836}{2240}$ tons of coal,	$ 8,612 37
Labor,	21,008 72
Oil waste, etc.,	2,374 30
Mill supplies, renewals, and repairs,	10,205 16
Total,	$42,200 55

DISTRIBUTION OF COST PER TON OF ORE TREATED.

	2240 lbs.	*2000 lbs.*
Fuel,	7 cts.	$6\frac{1}{4}$ cts.
Labor,	17 "	$15\frac{1}{4}$ "
Oil waste, etc.,	2 "	$1\frac{7}{10}$ "
Mill supplies, renewals, and repairs,	8 "	$7\frac{1}{2}$ "
Total,	34 "	$30\frac{7}{10}$ "

Mr. Blake claims that, had the ore been reasonably dry instead of being generally wet and, during the winter months, frozen, or if the crushing after the passage of the 30 by 5 crushers had been "wet" instead of "dry" and the screening in that way made perfect as it can be, the actual average daily product could have been increased, and the cost of crushing and concentrating per ton of crude ore reduced to less than twenty-five cents.

Whenever there is a sufficient difference in the specific gravity of an ore and its gangue, jigs can be worked with advantage to separate the one from the other and produce concentrates, and it is owing to the relative weights of apatite and magnetite (viz., about as 3 to 5), that it is possible to remove in part the phosphorus from an ore in which it occurs as apatite. Analyses given in the paper of Messrs. Maynard and Kunhardt, show that at the Lyon Mountain Works the proportion of iron in a concentrated New Jersey ore was increased 56.8 per cent. from what it was in the crude ore, while the phosphorus in the concentrates showed a decrease, of 65.6 per cent. as compared with the proportion in the crude ore.

The extent to which phosphorus can be eliminated largely depends upon the size to which each particular ore is reduced for separation and the intimacy of the admixture of apatite. We shall discuss this subject further in describing other concentrating plants in the future, giving some valuable analyses.

We would remind our readers that the problem to be solved at the separating works just described and at the Iron Mountain, Missouri, which is referred to in the description of that interesting ore deposit in this issue, are quite different.

The Chateaugay ore is a magnetite and that which is carried to the separators consists of grains of magnetite disseminated through granite rock. The reduction in size is performed entirely dry by crushers to one-fourth inch mesh, and the separation is made with water in the rotating jigs.

The Iron Mountain ore is a red hematite or specular ore; no crushing is done, the material being sized from egg-size down to one-eighth inch, and the separation is performed in washers and in tray-jigs with water.

As we have given the number of workmen employed at the Iron Mountain separaters, we may mention that at the time of our visit the following were employed at the New Concentrating plant at Lyon Mountain, New York:

One manager has charge of the works, which are operated continuously, except during the Sabbath. The day's work is divided into two shifts, of eleven hours each, an hour being allowed between shifts for repairs, cleaning jigs, etc. Each shift consisted of

Two men unloading ore from cars.
Four men feeding large crushers (two to each crusher).
Two men at intermediate crushers and screens.
Two men at multiple jaw crushers and screens.
Three men at jigs (one man to two jigs).
One engineer.
One fireman.

In addition, laborers were necessary to load the concentrates into cars, unload coal, remove ashes, etc.

Taking the figures given by Mr. Blake, and allowing ten tons of concentrates for every thirty-two tons of crude ore, we have 34 cents × 3.2 = $1.09 as the cost of producing one ton of concentrates.

But to this must be added an allowance for interest and depreciation bringing the cost of separating one ton of Chateaugay ore close to $1.50. The plant at Lyon Mountain is reported to have cost about $70,000, but a part of this expenditure was due to the location which made expensive trestles necessary for delivering crude ore to and removing concentrates from the works.

But as the lean ore is mined with the rich magnetite, the plant is probably a good investment for the owners, and its operation will undoubtedly be made less costly in the future Mr. Inman, the general manager of the Chateaugay Ore and Iron Company, is certainly deserving of praise for his energy in attempting the solution of a problem, which had cost others so much money and had at that time produced such unsatisfactory results.

To our mind, the question to be determined, is how lean the material which is taken from the mine can be successfully treated in the separators; as this lean ore is sorted from the shipping lump ore, it goes either to the dump or to the separators; it has been paid for in mining, and, therefore, the only cost to make it valuable is the expense of separation. We, however, do not consider, that in the present state of our knowledge we have yet found a wet method of concentration which will compensate an owner to work a mine which furnishes lean ore only; for the present, jigs must be confined to utilizing the ore which is taken out with shipping ore from mines now worked.

We acknowledge the courtesy of the use of the cuts in this article, to Dr. R. W. Raymond, Secretary of the American Institute of Mining Engineers.—EDITOR.

New York Mining Law.

In the transactions of the American Institute of Mining Engineers, Vol. XVII, Dr. R. W. Raymond, Secretary, discusses the Mining Law of New York, as contained in Title XI, Chapter IX., Part One, of the Revised Statutes, and claims that enlightened statesmanship should abolish the whole of it, and give all mineral deposits, out and out, to the owner of the land. In his interpretation of the New York Mining Law, Mr. Raymond, says:

"The word mine is evidently used throughout in the sense of a mineral deposit upon which a mine may be opened. The distinction between mines and quarries or diggings, is not recognized.

"The first three sections apparently assume the sovereign right of the State to all mines of whatever metals or metallic ores within its borders, and proceed to divide this property of the State into two classes, one of which is bestowed upon the private land-owner, and the other reserved to the State. In the first class are put practically copper, tin, iron, and lead mines only, and not even these, unless the land-owner be a citizen of the United States. Into the other class go all the rest. The peculiar phraseology seems to be intended to protect the citizen land-owner possessing a mine, the chief value of which is in one or more of the four metals named, from any claim of the State based on the presence of some other metal in subordinate value.

"By implication, every non-metallic mineral deposit in the State is the property of the land-owner, whether he be a citizen or not.

"Gold and silver mines belong to the State without restriction. Even if the ore of a mine be principally valuable for copper, tin, lead or iron, there is no grant of it to the land-owner, if the remainder-value be gold or silver. A mine of argentiferous galena, or auriferous copper pyrites, for instance, belongs to the State, however small the proportion of the precious metals. It is to be presumed that in construing this provision, judges and juries would require, to constitute a mine of gold or silver, a sufficient proportion of the precious metal to be actually a source of income to the miner. Mines of copper, etc., belong to the citizen land-owners; mines of all non-precious metals, to the State. But if two-thirds of the value of an ore is copper, etc., then the State will consider it as a copper, etc., mine, whatever may be the other non-precious metals contained in it."

"The sections, which regulate the working of mines belonging to the State, are curiously defective. The law could never have remained on the statute-book until now, except as a dead letter in all respects but one, namely, its grant to the land-owner of iron-mines, which, at this time, covers about all the valuable working metal mines in the State. Its reservation to the State of gold and silver mines and the "other metal" mines described, has never amounted to anything. In short, the provisions of the law that would have worked mischief, have never been called upon to work at all. Seldom has a blunder in legislation been so completely neutralized by Providence.

"The law passed February 6, 1789, appears to have been the first mining law passed in the State, and was the result of several petitions to the legislature, entitled 'An Act relative to mines.'

"We may conclude, on circumstantial evidence, that this law was framed to include in a general system the satisfaction of certain individual petitioners. In one case, at least, and not improbably in all the others, these petitioners were the owners of the land on which the mines mentioned had been discovered. Obviously, the provisions of the law which favor the land-owner were those of immediate significance, and the reservations in favor of the State were probably inserted on general principles, in the line of English precedents, and were not opposed by the petitioners or their friends, because they did not affect the cases represented in the petitions. In other words, these people were probably citizens, and discoverers of mines of copper, lead or iron (tin being out of the question), which they wished to own beyond dispute. It seems likely that the Ulster County petitions, at least, referred to lead mines, of which a number were discovered at an early day in that region. Whether the Dutchess County petitions mentioned copper, lead or iron, could perhaps be determined by an examination of the history of mining enterprises in that county. It seems to me unlikely that iron-ore deposits were the subject of the petitions, because there were not then, any more than there are now, in the State of New York, deposits valuable for the manufacture of iron which contain any considerable admixture of ores of other metals."

Manufacture of Russian Sheet Iron.

[Written for the JOURNAL OF THE UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS.]

There appears to be much misunderstanding in reference to the manufacture of sheet iron in Russia, and questions are frequently asked the writer: "What are the secrets connected with it?" "How is it made?" "Could admission be obtained to the iron works in the Urals, where this iron is made?" It is difficult to understand why such questions should be asked by persons versed in the literature of iron and steel, for Dr. Percy wrote a very excellent and accurate monograph on the subject a number of years ago. *

Not having had the opportunity of personally visiting the Russian iron works in the Urals, Dr. Percy's paper was compiled from

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*The Manufacture of Russian Sheet Iron. By John Percy, M. D., F. R. S., Philadelphia. Henry Carey Baird, 1871.

data furnished him by a number of persons who had actually visited these sheet iron works. Since it has been my good fortune to have the opportunity of seeing some of these works in the Urals, but a short time ago, I will, at the risk of telling an old story, briefly describe the process of manufacture as I saw it.*

The ores used for the manufacture of this iron, are mostly from the celebrated mines of Maloblagodatj and average about the following chemical composition: Metallic iron 60 per cent., silica 5 per cent., phosphorous from 0.15 to 0.06 per cent. The ore is generally smelted into charcoal pig-iron and then converted into malleable iron by puddling or by a Franche-Comté hearth. Frequently however, the malleable iron is made directly from the ore in various kinds of bloomaries.

The blooms or billets thus obtained are rolled into bars 6 inches wide, ¼ inch thick, and 30 inches in length. These bars are assorted, the inferior ones "piled" and re-rolled, whilst the others are carefully heated to redness and cross-rolled into sheets about 30 inches square, requiring from eight to ten passes through the rolls. These sheets are twice again heated to redness and rolled in sets of three each, care being taken that every sheet before being passed through the rolls is brushed off with a wet broom made of fir, and at the same time that powdered charcoal is dexterously sprinkled between the sheets. Ten passes are thus made and the resulting sheets trimmed to a standard size of 25 by 5½ inches. After being assorted and the defective ones thrown out, each sheet is wetted with water, dusted with charcoal powder, and dried. They are then made into packets containing from sixty to one hundred, and bound up with the waste sheets.

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*While this article was being put in type, the following appeared in a well known daily paper, and is here presented to show how tenaciously we hold to exploded romances.—ED.

"The secret of making Russia sheet iron is owned by the Russian government, and is such an immense monopoly that it is currently supposed to defray the entire expenses of the government. The works constitute an entire city, isolated and fortified against the rest of the world. When a workman enters the service he bids a last farewell to his family and friends, and is practically lost to the world. He is never heard from afterward, and, whether he lives or dies, all trace of him is forever lost. There have been several desperate attempts made to steal or betray the secret, but in every instance it has resulted in the death of the would-be traitor. In one case a letter attached to a kite which was allowed to escape, was picked up by some peasants, and, despite their protestations that they were unable to read, they were at once put to death by the guards to whom they delivered the letter, and it was afterward decreed that the guards themselves should pass the remainder of their days within the works."

The packets are placed one at a time, with a log of wood at each of the four sides in a nearly air-tight chamber and carefully annealed for five or six hours. When this has been completed the packet is removed and hammered with a trip hammer weighing about a ton, the area of its striking surface being about 6 by 14 inches. The face of the hammer is made of this somewhat unusual shape in order to secure a wavey appearance on the surface of the packet. After the packet has received ninety blows equally distributed over its surface, it is reheated and the hammering repeated in the same manner. Sometime after the first hammering the packet is broken and the sheets wetted with a mop, to harden the surface. After the second hammering the packet is broken, the sheets examined, to ascertain if any are welded together, and completely finished cold sheets are placed alternately between those of the packet, thus making a large packet of from 140 to 200 sheets. It is supposed that the interposition of these cold sheets produces the peculiar greenish color that the finished sheets possess on cooling.

This large packet is then given what is known as the finishing or polishing hammering. For this purpose the trip hammer used has a larger face than the others, having an area about 17 by 21 inches. When the hammering has been properly done, the packet has received 60 blows equally distributed, and the sheets should have a perfectly smooth mirror-like surface. The packet is now broken before cooling, each sheet cleaned with a wet fir broom to remove the remaining charcoal powder, carefully inspected, and the good sheets stood on their edges in vertical racks to cool. These sheets are trimmed to regulation size (28 by 56 inches) and assorted into Nos. 1, 2, 3, according to their appearance, and again assorted according to weight, which varies from 10 to 12 lbs. per sheet. The quality varies according to color, and freedom from flaws or spots. A first-class sheet must be without the slightest flaw and have a peculiar metallic gray color, and on bending a number of times with the fingers, very little or no scale is seperated as in the case of ordinary sheet iron.

The peculiar property of Russian sheet iron, is the beautiful polished coating of oxides ("glanz") which it possesses, if there is any secret in the process, it probably lies in the "trick" of giving this polish, as far as I was able to judge, from personal observation and conversation with Russian iron masters, the excellence of this sheet iron appeared to be due to no secret, but to a variety of conditions peculiar to and nearly always present in the Russian iron works of the Urals. Besides the few particulars already noted in the above description of this process, it should be borne in mind that the iron ores of the Urals are particularly pure and that the fuel used is exclusively charcoal and wood. Another and equally as important consideration lies in the fact that this same process of manufacturing sheet iron has been carried on in the Urals for the last hundred years. As a consequence, the workmen have acquired a peculiar skill, the want of which has made attempts to manufacture equally as good iron outside of Russia, generally less successful. It is difficult to understand what effect the use of charcoal powder between the sheets as they are rolled and hammered has upon the quality. It is equally as difficult to understand the effect of the interposition of the cold finished sheets upon the production of the polished coating of oxide. The Russian iron masters seem to attribute the excellence of their product more to this peculiar treatment than to any other cause. One thing is quite certain, there is no secret about the process, and if the Russian sheet iron is so much superior to any other, it is due to the combination causes already indicated.

F. LYNWOOD GARRISON.

Philadelphia, Pa.

THE importance of the iron industry to the railroads is well told by a resumé of the annual report of the Mahoning Valley Iron Manufacturers' Association for the year ending July 1, 1888. Although owing to the coke strike the blast furnaces were not continually active, the figures show as follows:

	Tons.
Blast furnace receipts,	1,182,629
Blast furnace shipments,	306,757
Rolling mill receipts,	411,848
Rolling mill shipments,	196,421

The local railroads moved a total of 321,937,636 tons one mile and were paid for freight the sum of $1,685,496.46.

Obituary.

For the first time in the history of the United States Association of Charcoal Iron Workers, the members mourn the loss of a presiding officer, Samuel Noble, president of the association, died August 13, 1888, at Anniston, Alabama, aged 54 years.

It has been our pleasure to know Mr. Noble for years, and it was with no small degree of gratification that we looked forward to the annual meeting of the association at which he was to preside, and which he desired held at Anniston, Alabama, for the success and advancement of which he had worked so zealously. We had arranged to visit Anniston in advance of the meeting, to confer with Mr. Noble as to the plans for the enjoyment of the members. But he has been summoned hence and we may well mourn his loss, remembering his universal courtesy and kindness and recalling what he accomplished while with us.

No marble or granite shaft is necessary as a memorial to him. Anniston is the monument to Samuel Noble, a monument which will continue to grow in beauty and importance and be sufficient not only for his memory but for those who were associated with him in its enterprises, and who shared with him the burden of its development. Few men have passed away whose loss has been so keenly felt by his neighbors, for we learn that at his death nearly every business house in the beautiful city of Anniston was draped in mourning and on the day of his funeral business was suspended in furnaces, shops, stores and mills, the population attending the obsequies *en masse.* May his memory long remain fresh with his neighbors who knowing him best esteemed him most.

Mr. Noble was a native of Cornwall, England, born in 1834, he came to America when but three years of age, residing with his parents in Pennsylvania until 1855, when the family moved to Rome, Georgia, where the father and sons established an iron foundry and machine shop.

In 1873 Mr. Samuel Noble, associated with General Tyler, of Connecticut, built the pioneer blast furnace stack of the Woodstock Iron Company at what is now Anniston, and from this beginning has grown all the industries and business of the progressive Alabama city. Its furnaces, foundries, cotton mills, handsome business blocks, commodious hotel, beautiful homes, elegant churches and schools are the result of the business enterprise and energy of the Nobles and the Tylers, and of these Mr. Samuel Noble was most widely known and second to none in his activity.

We know that we speak the wish of the members of the Association when we offer its condolence to the widow, the children, the aged mother and the brothers of its late president. We have considered it appropriate to place the portrait of Mr. Noble as a frontispiece to the JOURNAL and have to acknowledge the courtesy of the Iron Age for the opportunity of doing so.

◆

MR. C. R. BOYD, of Wytheville, Va., has complied and issued in a very convenient shape a map of South-west Virginia, showing the mineral resources and railway facilities of that section of the State, with a table showing the principal products of the different counties.

◆

PIG-IRON PRODUCTION IN GERMANY IN 1888.—The production of pig-iron in the German Empire, including Luxemburg, in the first half of the current year amounted to 2,106,714 tons, against 1,848,481 tons in the corresponding half of 1887, an increase of nearly 13 per cent.

◆

MANGANESE.—The total production of manganese ore in the year ending December 31, 1887, was 34,524 gross tons, valued at $333,844. The production of manganiferous iron ore was 211,751 tons, valued at $600,000.

◆

IT is stated that the mining industry of the world represents a value of $1,220,000,000, or nearly five per cent. of the annual products of human labor.

Queries.

We propose introducing a feature in the JOURNAL which it is expected will meet with a favorable reception, and give to our readers much valuable information. This will consist of answers to questions suggested by the editor, which concern the daily practice of those interested in the mining of iron ores, their smelting or in manufacturing the metal produced. It is the intention to have these queries answered as far as practicable, by persons skilled in the specialty considered, and to have them treated in a practical, rather than in a strictly technical, manner.

We present the first instalment of these queries and answers, and shall welcome any discussion upon them by the readers of the JOURNAL. It is but just to the gentlemen who have kindly contributed the answers, to note that the replies coming as letters, are published in their original form with only such editorial revision as was deemed essential.

In the three queries published we have endeavored to treat of subjects, which are practically of the same general tenor, viz: the influence of the composition or physical structure of ores upon the operation and output of the blast furnace.

QUERY NO. 1.—*Why is it difficult to make good foundry pig iron from a burden of all magnetites?*

Good "foundry iron" may be considered a comparative term, for a brand unexcelled for some purposes, may be almost worthless for others, and *vice versa*. Within recent years these distinctions are being made with some intelligence and judgment, but there is still room for improvement. Used in a general sense, good foundry iron may be considered soft, open-grained pig irons, best adapted to the greatest variety of foundry work and capable of carrying a large percentage of scrap. For special purposes, equally as good foundry iron can be made from all magnetites as from any other mixture of ores, but as a rule, irons made from magnetic ores exclusively will not rank as high as those made from mixtures consisting largely of brown or red hematites.

The difficulty of producing a large percentage of foundry iron with magnetic ores was more marked with the small anthracite furnaces of former years than with the larger and better equipped plants of more modern construction. The use of a portion of coke has made the management, also, somewhat easier and consequently enabled the percentage of foundry iron produced to be increased.

The difficulties attending the production of a large percentage of foundry iron from all magnetic ores, are due to several causes. Mention will only be made of the leading ones. Within certain limits, the greater the ease with which the iron of an ore parts with its oxygen, the more regularly and rapidly will the furnace perform its work of reduction and melting, and the hotter will be the crucible with the same weight of fuel. That the reduction of magnetic ores proceeds more slowly than of brown hematites, or red oxides, is probably due as much to their mechanical structure, as to any difference in chemical composition. Most of magnetic ores available in the Schuylkill and Lehigh Valley districts of Pennsylvania, are dense, close, compact ores. These ores, even when entirely free of sulphur, are more or less difficult to work, especially when filled into furnace in large pieces or masses, too heavy for one man to conveniently lift into a charging barrow. The writer has seen the dense New Jersey magnetics so filled into furnaces and at the same time the managers were complaining of the impossibility of making foundry grades, and the tendency of the furnace to work irregularly, or to run off on white iron, without (to them) any apparent cause.

The furnace gases experience more or less difficulty in penetrating, breaking up and de-oxidizing dense ores; they can be broken down more cheaply with hammers, open porous ores, or ores containing considerable combined water, are quickly and thoroughly permeated, in consequence, with magnetites there is a greater consumption of heat in the lower parts of the furnace and from the presence of ore, only partially reduced, there is apt to be sudden variations in the temperature of crucible. One of the conditions requisite to the production of a large proportion of the higher grades of foundry iron is almost absolute uniformity of temperature of the lower parts of the furnace. The crucible and boshes seem to acquire certain shapes or proportions, by graphitic accumulations, without which uniform soft grades of No. 1 and No. 2, x iron can scarcely be made. Time is required to form these accumulations of graphite, &c., but they are quickly and easily disturbed, and the disturbing cause seriously affecting the product of foundry iron. The use of magnetic ores exclusively renders these disturbances more frequent and less subject to control, owing to the difficulty of thoroughly de-oxidizing them before reaching the crucible. With magnetites forming the burden, the rapidity of travel of the stock in the furnace needs to be very carefully watched, and the composition of the slag kept as uniform as possible. Any considerable variation in slag, or too rapid or too slow driving (variations that would pass unnoticed with easily reducible ores), are reasonably sure to produce marked changes in the furnace running on dense magnetites.

The objections to structure do not hold good so far as the soft earthy magnetic ores are concerned. These ores, on the other hand, usually carry considerable sulphur, an element which is well known as an unrelenting enemy of foundry irons. When present in the dense class of magnetic ores, it entirely unfits them for the *economical* production of foundry iron. When thoroughly washed, however, these form fairly good mixtures, as the washing not only removes the sulphur, but, also, opens the structure of the ores, rendering them porous and easily attacked by the blast furnace gases. Brown hematites and red oxides rarely carry sulphur to any considerable extent, which alone is a decided advantage in their favor in competition with magnetic ores.

Soft magnetic ores, free from sulphur, are fairly well adapted for making foundry grades; with these forming a large part of the burden no particular difficulty is experienced in making open-grained iron; this would indicate that the difference in chemical constitution between the magnesia and the red oxides is not responsible for the greater difficulty experienced in reducing magnetites.

The grain or fracture of foundry iron by which it is graded, does not always indicate how it will work after re-melting. The writer has seen large, dark-grained and evenly crystallized iron condemned because it run hard in small thin castings. The fracture of the iron was all that could be desired, and it also had the soft appearance that is familiar to the expert, but difficult to describe. This iron proved hard in small castings, owing to the low percentage of silicon it contained (from 0.6 to 0.8 per cent.), and even when melted, without the addition of any scrap, would form a slight chill or hard shell on the surface of a casting in immediate contact with mold. Experiments in the pig beds showed that this metal gave from $\frac{1}{16}''$ to $\frac{1}{8}''$ chill as tested in Whitney chill cups.

Foundry irons made exclusively of magnetic ores, whether they be close and dense of structure or of the soft earthy varieties, are apt to show this tendency more or less; it is this want of uniformity that renders them undesirable for general foundry work, except as mixtures to strengthen the softer or weaker irons. While low silicon in the pig iron is undesirable for foundry grades, yet for mill irons this quality becomes valuable. Hence for the best brands of either grade, the average consumer of foundry iron will consult his interest in purchasing his standard iron from furnaces making a specialty of this branch of the business, while the mill manager will avoid the forge grades made by the foundry furnaces and seek his supply of best iron from those blast furnaces, making a specialty of mill or grey forge pig iron.

As a rule the gangue of magnetic ores contains but little free quartz or sand, the silicon is usually in combination with alumina, lime or magnesia, and the slag to this extent is partially made, so that the limestone flux added to ore charge to produce slag of certain composition, combines with the gangue of the ore more readily and at lower temperatures than when the gangue is chiefly quartz and sand. In consequence the iron made is less liable to contain reduced silica.

Other causes affect the percentage of silicon in the pig—but they pertain more to the management of the furnace itself than to the ores smelted. Large furnaces and super-heated blast permit of the production of high silicon foundry iron without particularly affecting the economy of the work.

The low silicon foundry irons, made from magnetic ores, give varying results in the foundry, depending upon the knowledge of foremen of melting departments; these irons, when also low in phosphorus, require more fuel to melt them and to run them as fluid as irons rich in silicon and phosphorus, but the difference in cost of fuel per pound of iron melted is but trifling.

While this fact is known to many founders, yet others conduct their cupolas without regarding the different requirements of irons of various compositions, and as a result, many imperfect castings are charged to the iron used when the fault really lies in the management of the cupola.

The grading of foundry iron is troublesome and annoying, conditions altogether independent of chemical composition change the grain or fracture by which the pig iron is graded, bought or sold. Attention has lately been called to this subject, and I have only to add that frequent mistakes are made at the furnace by breaking and grading pig iron when too warm. Sample pigs are usually taken from about the middle of each bed of the cast.

The pigs should be cold—the temperature of the atmosphere. If only moderately warm the grain will show larger, darker and more even crystallization than when broken entirely cold.

If a pig is broken warm and then broken again after losing all its heat, the first fracture may show No. 1 grade, while the second, even within a few inches of the first, will be only No. 2, or silver gray. All irons do not alter to the same extent; possibly the higher the silicon and phosphorus, the more difference there is in the appearance of the fractures of the same pig broken warm and then cold.

EDGAR S. COOK,
Manager Warwick Iron Co., Pottstown, Penn'a.

QUERY NO. 2.—"*What are the difficulties to be overcome in using concentrated magnetic ores in the blast furnaces?*"

My experience has been chiefly with concentrated Chateaugay, (Lake Champlain) ore, and we have had so little trouble with it that I feel almost justified in saying that I do not know of any difficulties in its use, up to say 50 per cent. of the ore mixture which is the most I have tried. We used some 10,000 tons of concentrated Chateaugay ore in our Scranton furnaces in 1887, and expect to use a much larger quantity this year. For the past two months (June and July), we have been running the four Scranton blast furnaces, which are in operation, on one-sixth concentrated Chateaugay ore. They have worked just as well as when we were using ordinary furnace ores, no increase of pressure, no irregularities and no trouble of any kind. A few days since I doubled the quantity of concentrated ore in use on our No. 1 furnace (73 feet high × 20 feet bosh), running it up to $\frac{1}{3}$ of the ore charge. The only other change made was a slight decrease of limestone. The speed of the blowing engines and all other conditions being kept the same as before. I rather expected some increase of pressure at the tuyeres, but such has not been the case.

The furnace was working well before the change was made and has worked just as well since No increase in pressure of blast. No decrease in the number of charges per day and no irregularities of any kind. The fuel used is $\frac{1}{5}$ coke and $\frac{4}{5}$ Lackawanna anthracite.

During 1887, we ran our No. 5 furnace (70 feet × 19 feet) for several weeks on 50 per cent. concentrated Chateaugay ore. When we made this trial I anticipated a considerable increase in pressure of blast and in order to meet this increased the proportion of coke to one third. I afterwards concluded that this increase of coke was unnecessary, as the pressure of the blast went down considerably. The furnace worked well on 50 per cent. concentrated ore and showed no peculiarities.

None of the concentrated Chateaugay ore is coarser than what will pass through a quarter-inch hole and most of it very much finer.* As different blast furnaces work differently, I would recommend parties commencing the use of concentrated magnetite to try a small proportion at first, say $\frac{1}{12}$th, and then gradually increase.

E. S. MOFFAT,

General Manager Lackawanna Iron and Coal Company,
Scranton, Pennsylvania.

QUERY No. 3.—*What are the conditions governing the production of different grades of pig iron?*

The grade of iron is dependent upon the following conditions:

First. Upon the chemical composition of the individual ores. A high manganese pig cannot be produced from an ore low in manganese, or a low phosphorous pig from phosphoric ores.

Second. Upon the chemical composition of the whole mixture. Reduction of manganese is facilitated by a strongly basic condition of the slag-forming constituents of the mixture; sulphur is eliminated by a strongly basic slag. Moreover, the melting point of the slag produced depends upon its chemical composition.

In general, the greater the amount of elements more difficult to reduce than iron (silicon, manganese, etc.,) it is desired to reduce

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***The concentrated Chateaugay ore referred to is the product of the works described and illustrated in this issue. Some of this ore is used regularly at the blast-furnaces of the Bethlehem Iron Company, the Edgar Thomson Steel Works, etc..—ED.**

and cause to alloy with the iron, the higher the melting point of the slag must be.

Third. Upon the mineralogical condition of the constituents of the mixture. The temperature of formation of the slag is more important than the melting point with regard to the grade of iron produced, and depends upon the amount of silica in the slag, and the condition in which the slag-forming constituents exist. The different reducibility of different ores also must be taken into consideration. In smelting difficultly-reducible ores, more iron is slagged off than when smelting easily reducible ones. It is also harder, in the first case, to produce iron high in silicon, carbon or manganese.

Fourth. Upon the temperature of the melting zone of the furnace. The reduction of manganese and silicon in large quantity requires high temperatures, so that high silicon or manganese pig cannot be produced in a furnace working cold. The temperature of the furnace depends upon the temperature of the blast, the nature of the fuel, the proportion between fuel and ore, and the heat consumption of the furnace. The latter is greater when large amounts of manganese and silicon are reduced, and when smelting difficultly-reducible ores, than in the reverse case. All these conditions together, cause a larger fuel consumption and the employment of a more highly heated blast, the higher in silicon or manganese the pig is desired to be.

Fifth. Upon the quantity of blast which the furnace receives in unit of time, or more correctly, upon the proportion this amount of air bears to the cubic capacity of the furnace. The more air a furnace receives the quicker the smelting proceeds and the greater the quantity of iron produced, but the more easily unreduced iron may be slagged off, and the less the amount of silicon and manganese reduced. Therefore a furnace making white iron requires closer watching than when making grey iron or high manganese iron. By the proper mixing of several ores, or by mixing the same with suitable flux, different grades of iron may be produced from the same ores, even when the original condition of the ores appears to be more suitable for one purpose than the other. Bog ores, intimately mixed with quartz or quartzy red hematite ores nearly always promote the production of grey iron; on the other hand high manganese spathic ores when used to produce grey iron have a tendency to make the iron white if cooled suddenly, and this effect is still more marked if white iron or speigel is produced, a large amount of alumina in the ore makes it more suitable for making grey than white iron, because it raises the temperature of formation and melting point of the slag. Conversely the production of grey iron is more difficult if ores low in alumina are used.

It is self-evident that in the production of a specified iron no ore should be used from which elements detrimental to the employment for which the iron was intended might be introduced. The employment of spiegel generally requires freedom from phosphorous; this is also the case with grey pig for bessemer use. It would be absurd to smelt phosphoric ores for this purpose. The amount of phosphorous is of small importance in foundry or ordinary white iron, the basic Bessemer or Thomas process requires a high phosphorous pig; for this purpose phosphoric ores are employed. A large amount of manganese is detrimental to foundry iron, as it has a tendency to make it slightly harder and whiter. For making white iron it is more advantageous than detrimental. High phosphorous manganiferous ores are more suitable for the manufacture of white iron, while low manganese ores may be employed for both purposes, but are better adapted, especially if high in alumina, for grey than for white iron.

The purpose for which the ore is used must depend upon the above considerations, according to its nature.

Independent of the size of the furnace the character of pig iron produced has a very marked influence upon the daily output.

The out-put of a given furnace being greatest when running on white (or high) irons, the production when different grades of iron are made has been found to be about as follows:

White (or high) pig iron,	**100**	**tons.**
Grey (or foundry) pig iron,	**65**	**"**
Spiegeleisen (10 to 12 per cent. manganese),	**60**	**"**
Speigeleisen (high manganese),	**40**	**"**
Ferro-manganese (60 per cent. manganese),	**25**	**"**

Translated for the JOURNAL OF THE UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS, from "Ledebur's Handbuch der Eisenhüttenkunde, Vol. II, p. 521, by

EDWARD K. LANDIS,
Analytical Chemist, Philadelphia.

The Electric Motor in Mining Operations.*

The electric system is the simplest method known for transmitting and distributing any amount of energy from one locality to another, irrespective of the intervening distance; and with it small and large amounts of power can be transmitted economically and profitably short or great distances.

* * * All dynamos are essentially the same, consisting of an armature or rotating part, and the field-magnets or stationary part. Practically, nothing to wear out, or give out. A well-proportioned machine has an efficiency of over 90 per cent., and would outlast, twice over, the steam-engine driving it (if it be driven by this means).

* * * An electric motor is a dynamo, in every sense of the word; but instead of being driven it uses the electricity and drives; one produces, the other consumes. A dynamo, producing electricity and driven by steam or water; and two copper wires necessary for the complete metallic circuit, leading from the dynamo across the country, no matter what its nature, to the locality where the motors are located. This is all. Ordinarily, for convenience of application, motors are of a different shape from dynamos, but they could be identical.

The line-wire once put up, in a substantial manner, at a constructional cost of a few hundred dollars per mile, is up for all time, and requires practically no attention.

Compare such a line with piping or wire rope; compare dynamos and motors, with no more machinery about them than an emery-wheel, with your steam or gas-engine, your hydraulic or pneumatic motors—if there are any such—and what can the decision be but favorable to electricity?

There are similar advantages in application. There is no such varied capacity in either steam, gas, air, water or cable. Can we hoist, haul, transport, pump, ventilate, drill, blast, light or heat, by any one of these? We can by electricity, and it is being done every day in the year.

* * * There is no limit to its production or transmission. It is *possible* to transmit the total available power of Niagara Falls,

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***Excerpted from a paper by Mr. George W. Mansfield, in Transactions of the American Institute of Mining Engineers, Vol. XVI.**

some 7,000,000 h. p., to Boston But, would it pay ? is the question to solve. Taking all the electric-lights throughout the country, and roughly figuring, we find that there is fully 250,000 h. p. engaged in producing electricity every night in the year. * * * I think it safe to say, that for every h. p. used in mining there are ten employed in producing electricity. * * * An arc-light consumes about .8 of a horse-power of electric energy ; now there are almost innumerable circuits from 10 to 50 miles long throughout our country with arc-lights indiscriminately placed their *entire* length. This is practically transmitting power ; for a motor could be placed where any one of the lights is. Abroad, Marcel Deprez has transmitted 40 h. p. through 70 miles of wire, with a commercial efficiency of 56 per cent. Mr. Brown, in Switzerland, has put into practical operation a plant transmitting 50 h. p. 5 miles, with a commercial efficiency of over 70 per cent. The Thomson-Houston dynamos are over 90 per cent. efficiency, as are also their motors. Therefore, if a steam-engine dynamo and motor were placed side by side we would obtain, of the 100 indicated h. p. of the engine, over 81 h. p. in mechanical power from the motor.

To whatever distance we remove the motor from the dynamo we lose power in the circuit. Copper is the best conductor of electricity, and yet this offers resistance. To decrease this resistance, we have to increase the conductors in size. This point is similar to the general practical rules governing hydraulic transmission. * * *

Motors have been used successfully for drilling by impact and boring with diamond drills. The latter method was successfully used several years ago by M. Taverdon, in France, and in his experiments he was fully able to compete with steam or compressed air. In rapid tunneling, in running adit-levels, in deep and crooked workings, or in all work requiring hasty construction, the great trouble and expense of shifting and relaying pipes, with great losses due to leakage, etc., is avoided. The necessary wires are simply cleated to wall or posts as work advances, thus always being entirely out of the way. In surface-work, the area over which we can work before changing steam-plant is vastly increased. In any direction, over rocks, hills or gullies, on a straight line run the wires, for miles if desired, and drilling and boring can still go on. In excavating, the cranes, shovels, scrapes, etc., may be run with other motors, taking power from the same wires. These applications have already been made, hence it is needless to enlarge. One other point: the wires once in place, none but casual inspection is needed to keep them in order; whereas, with compressed air, steam or hydraulic-power, a set of men is required to be constantly on hand, repairing, changing, etc. Furthermore, the room which pipes, etc., occupy in the shafts is by no means small, and is an important item to be considered, as compared with wires.

In competition with electricity under this head there can be mentioned only two systems—compressed air and steam. Considering the former, its excessive first cost puts it out of the comparison, except in underground work. Here its redeeming feature is the introduction of fresh air. This is, no doubt, a valuable adjunct; but a mine ventilated by electricity, as it could be if electricity was used for drilling, etc., would not require compressed air for the benefit of the men. * * *

For short distances only, and in open work, steam may be more advantageously employed; beyond these conditions it cannot be considered a competitor.

With an abundance of water-power, located within a few miles of a mine, there is no reason why we cannot hoist entirely by transmitted electricity as economically as by steam. * * *

In all placer-mining, and mines of but a few hundred feet in depth, where there is uncertainty as to the location of workings, or the permanence of the location temporarily selected; in all preliminary explorations, etc., the electric motor is so easily moved and applied, and its scope so great, that it is vastly cheaper and better than any other means, beyond certain limits. In very deep and large mines, however, permanently located, probably steam, acting direct, is to be preferred.

The case, although not exactly similar, is analogous to the application of motors to elevators in our buildings. There are scores applied to this purpose, hoisting many tons in weight, and with speeds from 30 to 130 feet, and more, a minute; many of these have been in daily operation for from three to four years.

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There are in the aggregate, in this country, about 125 miles of electric railways operated to-day; the motors propelling loads of

10 tons, at speeds of 1 to 15 miles per hour, to distances of 8 miles, and over grades of 10 per cent. Probably 2,000,000 passengers are now annually carried on these roads. On the elevated railroad of New York city, the weight of the motor was 9½ tons, and capacity about 100 h. p. With this motor the four regular coaches, nearly full of passengers, were drawn over a distance of two miles, and up grades of 2 per cent., at an average speed of eight miles per hour. I believe this is the largest experiment of its kind that has ever taken place in this country.

In the application to mining work, the principles involved are plainly the same, the change being only in detail. There have been already numerous applications abroad, and one in this country. The best known application to mining haulage was made in 1882, at the Zankerode pit, near Dresden, in Saxony. The motors are of 6 h. p. capacity, and haul trains of from 10 to 20 wagons, each of about 3 cubic feet capacity, maximum weight 13 tons, at a speed of about 5 miles per hour. The length of track is ⅓ mile. The cost of operation has been about 1½ cents per ton. The total cost of the plant was about $4,000.

An interesting comparison from actual practice shows the ratio of cost of operating to be as follows:

Electric Traction.	Horse.	Man.
2.7	3.7	6.2

Since the above tests were made, great improvements have been made in the efficiencies of motors; hence, although the above is an excellent showing, a still better one could be made to-day. The efficiencies to-day of good motors range from 85 to 95 per cent.

Careful tests of the Ressbrook and Newry railroad, showed that its electrical efficiency was 72.7 per cent. From other sources we have proof that this figure is by no means excessive; and it is safe to say, that a plant installed with ordinary care in any mine would give from 60 to 70 per cent. electrical efficiency. * * *

The only system to be compared with the electric under this heading are those of the locomotive and the wire rope. In construction, the locomotive system requires nothing but the rails; electricity, the addition of an overhead wire, easily placed, and requiring practically no attention; and the wire rope, a line of sheave-wheels, upon the floor of the level, upon which rests the rope, in the way of any other traffic in the same level. With wire ropes, the room required at the mouth of level or incline for the gears, winding-drums, engine, etc.: the expense of repair and maintenance; the short life of the cable, its inapplicability for crooked workings, and, its enormous waste of power (since there never is obtained in useful work overcoming resistance of traction and grades, over 25 or 30 per cent. of the prime source of power) —all unite to render its adoption for mining work almost absurd, in view of the simplicity and practicability of the electric system. Except for hoisting, there is practically no place for wire ropes in mining operations.

The steam-engine worries with its complications and constant attendance; its heat; its smoke and gases, vitiating the air. For haulage, the steam-engine in mines is to be avoided. Through the adoption of the electric motor all these worriments disappear.

In transporting by the telperage system, wire ropes are stretched from post to post across country as desired; depending from these ropes are cars; the motor is placed in one of these cars, and drives up to the driving-wheels by means of belts, chains or gears. There is a very prolific field for application in this direction, and the stimulus necessary is the only thing now lacking for a general adoption in scores of places.

Abroad, the idea has been put into practical shape. The line at Glynde, England, is about one mile long, and used to transport clay. Trains of 8 or 10 skips are ordinarily made up, and when loaded the total weight is two tons. In every way it was practically and thoroughly tested, and it has given satisfaction. * * *

The practical application of the electric-motor for pumping is simple, since most manufacturers of pumps adapt them for belts or gears. The only thing, then, to provide for is a belt or a pinion for the armature-shaft. The intervening distance between the power-station, on the surface, and the point where the pump is needed, is of small consideration as regards construction, for copper wires can be easily run irrespective of distance or conditions. A plant, complete, consisting of 30 h. p. dynamo, 20 h. p. motor, with wires, insulators, etc., would cost about $3,200, and would be capable of doing—one mile distant from station—20 h. p. actual work in pumping water.

A number of applications have already been made abroad; notably at St. John's colliery, Normantown, and at the Thallern colliery, on the Danube. Another application is a small plant at the Trafalgar colliery, England: here, the duty of the motor was to pump 114 gallons per minute through 3,900 feet of 7-inch pipe, with a lift of 300 feet. The motor capacity was 10 h. p.; the operating expenses, per day of 22 hours, was $35; total cost of installation, $3,220; efficiency, 45 per cent.—*i. e.*, of the belt-power from engine to water thrown out, only 55 per cent. was lost. The cost of such a plant to-day would be undoubtedly diminished one-half. * * *

In large mines, especially in the coal regions, an enormous suction fan is placed at the mouth of the up-cast shaft, and the air is sucked through the entire system. Evidently where the men are working at the various headings, and in the stalls or rooms, the only way fresh air is obtained is through the construction of wooden boxes leading air in. This is extremely expensive, not only to construct but to maintain.

It seems that by the proper placing of numerous motors, each attached to a fan, a constant circulation can be maintained.

By dividing a mine into sections, and then by placing in the partitions between each section electric fans, all propelling the air in the same direction, a perfect system is to be had. Plainly, fresh air must be drawn in somewhere and the foul air expelled at another shaft.

For ventilating chambers, a small motor can be placed at the entrance of each near the top, blowing the air out into the general level, along which the main body of air is propelled.

Any mine in this country, with all its varied mechanical appliances, could be operated entirely by electric power; and I have no doubt that within a few years such a general application will have been made.

Mr. Mansfield's predictions may seem far too enthusiastic to many of our readers, but we recognize the fact that the progress made in the transmission of power by electricity and its possibilities are not generally appreciated. We add to Mr. Mansfield's remarks the following condensed from an article in the Engineering and Mining Journal:

"Electric mine locomotives are doing excellent work in the Pennsylvania coal mines, and present some evident advantages over the steam locomotive underground. The electric transmission of power in the mining districts has already developed an enormous market for electrical machinery.

We recently described an 18-mile installation for pumping, hoisting, etc., on the Big Bend of the Feather river, Cal., which is under contract.

In Arizona an installation is proposed to bring about 150 horse power from a waterfall to a large mine and smelting works, a distance of eight miles, and it is estimated that the conductors will call for eight tons of copper to the mile. On the Comstock it is proposed to use electric transmission to run, in part at least, the new Nevada mill. At present this mill, which has twenty stamps, is run by a Pelton impact water-wheel, 11 feet diameter using water under a head of about 650 feet. It is now proposed to take the water after it has driven this wheel lead it down the Chollar shaft to the level of the Sutro tunnel, where it will have about 1,600 foot head, and there drive another Pelton wheel of the same diameter.

The underground installation will consist of five dynamos, and the power will be transmitted to the mill at the surface, about 2,000 feet, through a ⅝-inch copper cable, and electric motors will then utilize it to drive the mill, which, as enlarged, will have sixty stamps, thirty pans, etc.

The consumption of water will be regulated to the power required to drive the mill, and it will undoubtedly be very much less with the sixty stamps than it now is with forty. As the water has to be bought, this will probably prove a substantial economy.

In the Consolidated Virginia and California mills the power has been transmitted through wire ropes from water wheels situated at intervals of 500 feet vertically in the shaft, utilizing the pressure down to the level of the Sutro tunnel; but faulty construction occasioned much trouble, which it is hoped can be altogether overcome by the use of electric transmission, which is to be tried should the Nevada mill experiment result satisfactorily, as it no doubt will.

A Silver City, Idaho, mine is putting in a Sprague electric plant, to drive a 50-stamp mill four miles away from a water-fall.

Many of our mines and metallurgical works are proposing to use electric locomotives, either with conductors or storage batteries.

Nearly all mills and furnace works use electric lights. Mining machinery, drills, coal cutters, pumps and hoisting engines will be driven in many places by what is now the waste power of neighboring water-falls, and before long we shall have few waste waterfalls."

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The Iron Mountain, Missouri.

The Iron Mountain of Missouri, probably more than any other single deposit of American iron ore, fails to be appreciated in its true relation, even by those who are fairly conversant with the iron ore resources of the country; for it is either considered as a mountain of iron ore, practically inexhaustible, and really the most important one in the country, or else it is looked upon as a rather unimportant and practically worked-out deposit. Neither of these opinions places the Iron Mountain in its proper position, and the exaggerated view first instanced is the natural result of the eclat attending the early development of what, from the magnificent showing of a hill whose top was formed of solid ore, and sides covered by large quantities of broken ore, was believed to be an inexhaustible deposit. The Iron Mountain is far from being unimportant or worked out, and cannot be said to be even fully explored; it has been and will continue to be one of the large American mines, as will be evident from the production for a series of years as given in this article.

The idea of possible exhaustion probably arose from the fact that when the iron ore which formed the crest of the mountain was removed, it was found that it really existed as a dome, covering and extending down into the porphyry; and when the interior of this dome was found to consist of veins or beds of ore in the porphyry, some of which were soon mined out, the impression gained ground that the Iron Mountain would not long exist as a prominent producer of iron ore. The unfortunate combination of circumstances which have prevented the pig-iron industry in the vicinity of St. Louis assuming the importance which it is natural to expect, and the apparent speedy exhaustion of the vein of ore worked on Pilot Knob within six miles of Iron Mountain, have had a tendency to belittle this really excellent source of iron ore supply. To understand properly the true position of this interesting deposit, the following statement of the production of some of the prominent iron ore mines of the country is presented:

OUTPUT OF IRON ORE FROM PROMINENT AMERICAN MINES.

	When opened.	Total production to January 1, 1888—gross tons.	Maximum annual product—gross tons.	1887 output—gross tons.
Port Henry mines, N. Y., ...	1804	8,746,600	447,754	447,754
Cornwall ore banks, Pa., ...	1740	8,673,000	688,054	667,210
Lake Superior mine, Marquette range, ...	1858	4,195,131	302,909	302,909
Cleveland mine, Marquette range,	1854	3,704,654	225,674	207,441
Republic mine, Marquette range, .	1872	2,811,450	277,757	220,624
Iron Mountain, Mo., ...	1845	*2,736,445	269,480	113,589
Jackson mine, Marquette range, .	1856	2,714,460	132,297	109,906
Chateaugay mines, N. Y., ...	1881	1,933,200	224,158	219,390
Champion mine, Marquette range,	1868	1,907,892	210,180	146,330
Chapin mine, Menominee range, .	1880	1,665,839	336,128	336,128
Pilot Knob, Mo., ...	1847	† 1,600,000	?	206,000
Lake Angeline mine, Marquette range, ...	1864	1,088,106	191,120	191,120
Norway mine, Menominee range,	1878	1,025,475	198,165	95,726
Vulcan mine, Menominee range, .	1877	1,021,341	205,036	205,036
Minnesota Iron Company's mines, Minn., ...	1884	986,256	394,252	394,252
Colby mine, Gogebic range, ...	1884	601,274	258,518	258,518
Norrie mine, Gogebic range, . . .	1885	357,517	217,254	217,254
Aurora mine, Gogebic range, . . .	1885	258,054	159,252	159,252
Ashland mine, Gogebic range, . .	1885	256,057	175,561	175,561
Inman mines, Tenn., ...	1886	194,251	102,601	102,601

*See note to table following,

† Estimated.

The iron ore shipments reported from Iron Mountain, Missouri, have been distributed as follows:

	Gross tons.		Gross tons.
Prior to and including 1870, .	791,077	Prior to and including 1880, .	108,045
1871, .	157,904	1881, .	77,434
1872, .	269,480	1882, .	62,043
1873, .	235,130	1883, .	51,352
1874, .	103,680	1884, .	47,220
1875, .	107,220	1885, .	52,993
1876, .	107,430	1886, .	138,082
1877, .	75,468	1887, .	113,589
1878, .	95,930		2,736,445
1879, .	142,368		

The Iron Mountain has therefore produced a total, to close of

1887, of 2,736,445 gross tons; but the production prior to 1870 is given only from the records on file, and as considerable ore has been removed of which no account was made, the output may safely be considered as exceeding three million gross tons to date.

In the JOURNAL, Vol. VI, pages 23 to 40, Professor W. B. Potter, of the Washington University, St. Louis, contributed a very interesting paper upon the group of mines forming the Iron Mountain region of south-eastern Missouri, accompanying the description by an outline map showing the four districts south of the Missouri river, from which the workable iron ores of the State of Missouri are obtained. It was our privilege lately to spend a day with Prof. Potter in examining critically the deposit of iron ore in the Iron Mountain and the methods employed in mining, finding so much of interest that we obtained permission to prepare the data for presentation to our readers. We shall not repeat from the paper which appeared in Volume VI of the JOURNAL, further than to give a few extracts, which will assist those who do not possess a full set of our publication, but others who are fortunate enough to have the paper prepared by Prof. Potter will find much of interest by referring to it in connection with the matter now presented.

GENERAL FEATURES.

The Iron Mountain is located eighty-one miles south of St. Louis; the original height of the hill was two hundred and twenty-eight feet above the railroad passing through the valley on the west side, and the area covered by the Iron Mountain and its spur, Little Iron Mountain, approximates five hundred acres. Prof. Potter says "the mountain is composed of red, brown, with some bluish porphyry, all more or less distinctly bedded, and the beds dip away on all sides with the surface slopes, thus exhibiting a rude, yet well marked, dome-like structure. The same dome form appears in the main ore vein, the top of which was originally exposed for an acre or more at the summit of the hill. Cutting through this in the subsequent working, the vein was found to dip away on all sides with the surface slopes, but at a steeper angle, following to some extent the bedding of the porphyry, yet inclining more rapidly."

After describing the extensive open cut which was carried down one hundred and thirty feet below the original top of the hill, and the huge marginal vein forming an irregular ellipse one thousand by five hundred feet. as well as the interlacing veins within this ellipse, and referring to the importance of kaolinization or decomposition of the hard porphyry rocks, Mr. Potter mentions what to us is one of the most interesting features of the Iron Mountain deposit, and one of the best evidences of the value of thorough scientific inquiry.

This is what is locally known as the "old surface ore," and was described by Prof. Potter in 1884, as follows:* "Over the whole western side of the original hill, and dipping away with increasing thickness, may be seen a very ancient bed of surface ore, composed of irregular and partly-rounded fragments of black, somewhat decomposed, ore. This passes beneath the overlapping sandstone and the limestone below, forming in the lower bed of the latter a remarkable ore conglomerate with limestone cement, * * * it will undoubtedly be found stretching away down the ancient hillside to where the latter runs into the bottom of the valley beneath the Silurian beds. * * * The quantity of ore stored up in this interesting deposit must be very large indeed, judging from the developments already made, and the great area over which it is found outcropping well up on the sides of the hill, and following down the slope, always with increasing thickness beneath the covering of hardened clays and shales. * * * Comparatively little clay or foreign matter, and no hard rock at all occurs with the fragments of rich, black ore."

LATE DISCOVERIES.

The discovery of this mantle of iron ore surrounding the deposit formerly exploited was not accidental, but was the result of patient study of the formation and thorough search, in the light of advanced science, for ore which ages ago had been eroded from the main deposit. The prophecies made four years since are being verified to-day, and the exposures and underground workings are truly wonderful. We believe that the investigations at Iron Mountain, Missouri, may go far to explain some of the peculiarities of other deposits of specular iron ore.

Professor Potter, who as mining engineer for the Iron Mountain Company has charge of the development of the deposit, considers that the ore was formed by deposition in the crevices and cracks of the porphyry, made by pressure from below, thus accounting for the heavy deposit on the crest of the hill, and the extension of the marginal and interlacing vein down into the porphyry rock.

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*Vide JOURNAL, Vol. VI, page 27.

Upon the slopes of the upheaved porphyry, detrital ore accumulated through a long period of erosion; forming a talus of varying thickness, caused by ravines and alternate ridges in the sides of the mountain. This detrital bed consists of more or less smoothed and rounded fragments of ore, varying in size from fine sand to masses three or four feet in diameter, all tightly compacted together, with a small amount of fine clay filling the interstices. It is rare to find rock fragments with the ore.

Owing to the ready decomposition of the porphyry country rock, such fragments as may have been free to roll down the mountain side would be kaolinized and washed away before coming to rest in the ore talus. The more quartzose and less destructible rock fragments would alone sustain the exposure and be found with the ore. The deposit is therefore wonderfully rich. The lump ore, larger than a hen's egg, is picked out underground and is ready for shipment at once, while the remainder constitutes rich wash-dirt, and is carried to the surface, turned over once with the hose to wash out fine clay, and then put through the separators. Average samples taken of the ore, just as it is blasted out in this deposit, show sixty per cent. of metallic iron.

Explorations have proven that this mantle of ore surrounds the mountain on three sides, and is in reality a noble deposit in itself, lying outside of, but enveloping the porphyry mass, from which was taken most of the ore that has made the Iron Mountain renowned. The older "find" increased in dip as it was followed down, passing from a flat capping at the summit of the hill to a vertical dip of the marginal vein at the sides, making the ore form a spherical cover or inverted cup; the interlacing veins also approximated a vertical dip. The new find, however, starts at a dip of about thirty-five degrees from the horizontal and flattens as it is followed down, the intervening mass between the two deposits being porphyry.

This ore is somtimes called "old surface ore," but is locally recognized as "black ore." Following down the dip it increases in thickness, and at a vertical depth of two hundred and eighty feet from the surface exposes magnificent breasts twenty, thirty and even fifty feet in height. The fragmental ore has been compacted and forms a mass, so that practically all the material removed is high-grade ore, mostly of Bessemer quality. Near the limestone roof the ore sometimes occurs mixed with the limestone—this must be crushed and separated to become merchantable.

MINING METHODS.

Mining is being actively prosecuted by underground workings in the new-found deposit, and the large open quarries of the older deposit are also being operated.

The policy of the management has been, as far as practicable, to furnish power from a central station conveniently located as to the ore openings and adjacent to the machine-shop and foundry. This power plant consists of two batteries of steam boilers connected to two Norwalk compound air-compressors, twenty by twenty-four inches, which supply air under eighty pounds pressure to from twenty to twenty-five rock drills (some of which are made in the company's shops), four pneumatic hoisting plants and four pneumatic pumps. There are also four hoisting plants operated by steam and a steam pumping-engine, which elevates over one million gallons of water daily from a neighboring stream of water to a reservoir three hundred and sixty feet above the source of supply. From this reservoir pipes bring the water one mile to the workings, where it is used for hydraulicking fine ore, old dumps, etc., as well as for supplying the washers and jigs at three concentrating plants or separators.

The hydraulicking is done with water under about one hundred and twenty-five feet head (fifty-five pounds pressure), large hose nozzles being used to turn the material over and wash away the clay which adheres to the ore. Some years ago an injunction was sought to restrain the company from allowing the washings from the separators and hydraulicking to find their way into the neighboring stream, but the right of the company was sustained; as the only proof of damage was that the tailings interfered with the fish. It is proper to note in this connection that the stream for several miles passes through the Iron Mountain Mining Company's property before entering the lands of others; for the estate immediately connected with the Iron Mountain embraces about twenty-five thousand acres.

ORE SEPARATORS.

There are three concentrating works or separators at the Iron Mountain, two of which were in operation at the time of our visit. Each of these has its own steam boilers and engine, and, although differing somewhat in detail of construction, may be described as follows:

The leaner ore from the mining operations, or the material which has been hydraulicked, is brought by carts or tram-cars to two wrought-iron washers, of conical form, with interior blades. Into these the material passes to revolving screens, made of cast-iron, in which there are holes one inch in diameter. All that passes through these screens is elevated by a system of chain buckets to the upper portion of the separator, and the remainder drops from the screens on to cars, where, if necessary, it is picked over. This large-sized material is recognized as "cone ore."

The finer ore, after being raised by the elevator buckets, passes through four revolving screens with holes, three-fourths, one-half, one-fourth and one-eighth inch in diameter respectively, the material of each size going to different jigs. The material which passes through the three-fourths, one-half and one-fourth inch screens is treated in six eccentric-tray jigs, two for each size; that which passes through the one-eighth inch screens goes to two crank-arm double-tray plunger jigs.

Elevator buckets remove the ore and tailings from each pair of jigs and deposit them in separate hopper bins, from which they are drawn into cars and carried to stock-piles or waste-dumps.

The product of one of these separating works is fifteen to twenty-five tons of dressed ore per hour, and the services of nine men are required after the ore is delivered at the washer. These are distributed as follows: Two men at washer; four men at jigs; two men removing finished products and tailings; one engineer. If working night and day, this force would be duplicated.

The fine old surface or black ore which is concentrated yields about one ton of separated ore for one and a half tons of material fed to the washers, but the material from the old dumps yields but one ton of separated ore from three or four tons of crude material.

The cost of hydraulicking and separating the ore which yields one ton for every three tons treated is given at one dollar per ton of separated ore. One ton of coal raises water to a height of three hundred and sixty feet to hydraulic and separate thirty tons of merchantable ore.

As the phosphorus occurs in this ore as apatite, the separated ore exhibits a material reduction of this element. One experiment showed in the crude ore 0.125 per cent. of phosphorus, and in the separated ore 0.05 to 0.06 per cent. phosphorus. Another test gave the following result:

	Iron.	*Silica.*	*Phosphorus.*
Separated ore, ...	65.37	4.03	0.027
Tailings, ...	28.30	43.42	0.189

The tailings show considerable loss, but as much of the iron is in the porphyry this loss is practically less than the estimates indicate.

In working over the old dump piles left from former operations, a class of ore is produced which is called "furnace jigged ore." This averaged in 1887,

Iron, . . 62.22 Silica, . . 8.00 Phosphorus, . . 0.10 *

GRADES OF IRON ORE.

The grading of the iron ore obtained from the Iron Mountain deposit receives close attention, and a larger number of classes of ore are produced than are offered in the market. Prof. Potter gives these grades in the JOURNAL, Vol. VI, pages 29 to 33. It may, however, be mentioned that there are three general classes namely, "surface ore," "vein or bluff ore," and "black or old surface ore." The following, collated from late analyses, represent the composition of the various grades produced. The average of the lump surface ore ready for shipment, which was mined during 1887, was

Iron, . . 67.02 Phosphorus, . . 0.028 Silica, . . 3.88

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* The operation of these separators may be profitably compared with those obtained by the Chateaugay Ore and Iron Company, as detailed in another article in this issue.—ED.

The "jigged surface ore," made by hydraulicking and separating, yields from sixty-four to sixty-six per cent. of iron, with phosphorus from 0.03 to 0.08, the average of the surface ore jigged in 1887 being

Iron, . . 65.20 Phosphorus, 0.052 Silica, . . 4.10

The "vein or bluff ore" is blasted out from the porphyry, and is divided into six grades, the "special" bluff ore averaging from 63 to 65 per cent. of iron, .012 to .018 of phosphorus, 5.0 to 6.5 of silica.

The "No. 1 Bessemer" bluff ore has from 62 to 65 per cent. of iron; phosphorus, 0.03 to 0.06; silica, 5 to 7 per cent.

The "No. 1 non-Bessemer" bluff ore yields 62 to 66 per cent. of iron; phosphorus, 0.06 to 0.3.

The "No. 2 Bluff" varies in iron from 55.5 to 63.75, in phosphorus from 0.1 to 0.5, and silica from 6 to 14.3. The average for 1887 was

Iron, . . 58.33 Phosphorus, . . 0.248 Silica, . 10.32

A grade known as "No. 3 bluff ore" is produced, but is not marketed, as it carries from forty to forty-five per cent. of iron only, but this ore is placed upon a separate dump, which in the future will be crushed and jigged.

The smaller lump ore or "spalls," which is produced in mining, carries from 45 to 50 per cent. of iron; phosphorus from 0.075 upwards; silica, 15 to 20 per cent.; this is also stocked for future crushing.

The finer materials taken from the bluff workings is known as "wash dirt," and is hydraulicked and separated.

The "black or old surface ore" is mostly lump and is shipped as mined. It carries from 60 to 64.5 of iron; phosphorus, 0.03 to 0.10; the average for 1887 being

Iron, . . 63.00 Phosphorus, . . 0.072 Silica, . . 5.13

The finer ore is hydraulicked and jigged, and the working of 1887 showed

Iron, . . 61.00 Phosphorus, . . 0.056 Silica, . . 6.5

A small amount of ore which is mixed with limestone is thrown upon the dump for future crushing.

ECONOMIC RESULTS.

Taking the work for last year, 1.5 tons of rock were moved per day per man employed in mining, and for each pound of explosives used 1.14 tons of ore and rock were removed. Out of each 1,000 tons of material removed from the workings 227 were rock and 773 were ore of all grades. The work performed by the drills was as follows:

The power drills worked by compressed air averaged 39.9 feet per day for each drill in use.

The hand drills averaged 9.51 feet per day for each drill in use.

The coal consumed to produce the power for operating the drills, hoisting machinery, mine pumping, and for the machine-shop, averaged one ton for every 40.31 tons of ore mined.

Steel Rail Manufacture.

Public speakers and newspapers have so constantly associated the word "monopoly" with our great steel rail mills, that those unfamiliar with the development and progress of this important branch of our industries, are apt to look upon steel rail manufacture as a business where small outlay brings large profits to a few wealthy men who control the business. Those more familiar with our industrial enterprises know that such is not the case, and recognize that while handsome fortunes have been made by some of those connected with our Bessemer steel works, it is doubtful if the earnings from them in a term of years have been as great, in proportion to the capital invested and the risks taken, as in many other branches of business. Familiarity with ingenious devices make us as a people expect to see automatic machinery in connection with the manufacture of articles in general use; and no one is surprised, although he may be delighted, at the mechanism which produces almost automatically and with mathematical precision the pins, needles, nails, watch movements, spools, thread, etc., which constantly meet our eyes. But in the manipulation of heavy masses and the manufacture of the more ponderous materials which are in demand, most persons are less familiar. An intimate knowledge of what is being accomplished daily in some of our great industries would, therefore, be a great revelation to many. who, in the absence of such information, join in the condemnation of enterprises which have been most potent in advancing our national development. Such were our thoughts after visiting, in three consecutive days, three of our great steel rail mills, located hundreds of miles apart—for although it has been our privilege to make numerous calls at these industries, we were impressed anew with the marvelous strides made by the judicious and liberal investment of capital, by patient and intelligent experimenting with appliances, by thorough and conscientious researches into the sciences, and by systematic development of labor-saving mechanisms.

We should be proud of these great industrial enterprises, and it is our belief that the fault finding so often indulged in would give place to genuine admiration were those who are now so outspoken in condemnation to make a tour of our great steel rail mills. For in them we see the triumph of mechanical ingenuity and engineering precision, and none can fail to be impressed with the magnitude and importance of the enterprise, which, starting from the great blast furnaces (whose economical operation challenges the admiration of the world), the molten metal is carried in ladle cars to the converting house—possibly being tipped en-route into the mixer, where nearly 100 tons of fluid iron is rocked to and fro. At the converting house the ponderous converters bow down to receive the metal from the ladle, and then rising belch forth the flame until ready to empty its charge into the ladle from which the ingots are cast. Steam or hydraulic power move the ladles, the mixer and the converters, lift and strip the ingots and convey them to the heating furnaces, soaking pits or hammers. These masses of metal are mechanically charged into and removed from the heating furnaces, carried to the blooming train, where they are raised, lowered or turned at will, thence to the roll train, the saws, the cooling-beds, and finally to the drill presses and straighteners; all by machinery, over which complete control is given by levers or throttles. In fact, steel rails as now made, may not have devoted to their production any manual labor more severe than is required to move a lever or wheel, from the time that the ore, flux and fuel are shoveled into the charging buggies which feed the blast furnaces, until the finished rail is ready for the straightener or drill press. Steam, air and water applied through proper mechanical means. and controlled by intelligent labor perform the severe work, which makes it possible for one of our rail mills to produce a rail 30 feet in length and weighing 600 pounds every 25 seconds. And these rails are perfect in section, variations of small fractions of an inch in thickness or contour being sufficient to insure their rejection.

In a description of the South Chicago works read before the British Iron and Steel Institute, by Mr. E. C. Potter, general superintendent of the North Chicago Rolling Mill Company, the statement is made that "the number of men and boys employed upon the rail from the time it is delivered to the blooming train until it is upon the cooling bed, is seventeen; and the cost for this labor is about eight cents per ton of finished rails." Mr. Potter also says that this train has rolled "over 1,800 rails, each 30 feet long, in twelve hours." This approximates a mile of finished rail per hour. We may therefore consider our great steel works as worthy of national pride, and rather glory in the fact that in many cases financial success has followed the energetic and judicious combination of money, brains, skill and labor, which has brought the manufacture of steel rails to such perfection. But financial success has not been the history of all American steel rail enterprises, on the contrary, large amounts of money have been lost in attempts to establish or carry on these industries, and the reason for the satisfactory results which have followed the development of this industry, may be found in the perfection of appliances and the employment of those skilled in specialties.

We have no interest in the steel rail industry, more than in any other branch of manufacture, but we are proud of all developments of American resources. Nor are we a champion for the manufacturers of steel rails, who are amply able to care for themselves, but we are desirous that the foresight, skill, pluck and energy which have brought into existence such magnificient industries should be properly appreciated, and we enter our protest against the envious spirit which too often is noticeable in the unwillingness to see others profit by reason of money risked or intelligence, skill and energy devoted to bringing an enterprise to a successful issue.

THE EDITOR.

The Terni Steel Works.

In a paper upon the machinery of the new steel works at Terni. Italy.* Mr. Hugh Savage describes the utilization of compressed air generated by water power, for purposes of iron manufacture not generally considered as within the economical range of this power; and presents information which may be of service to the readers of the JOURNAL. The large steel and iron works were located in 1884, at Terni in Central Italy, on account of the neighboring water falls, and the beds of lignite close by.

The river Velino is tapped at an elevation of 750 feet above the floor of the steel works and carried over four miles, through open canals, pipes and tunnels to operate the machinery; 2,900 yards of this distance is occupied by tunnels. The effective head at the works is from 270 to 300 pounds per square inch, the loss of head in conveying the water is equivalent to a pressure of 30 pounds and the effective force at the works is 8,000 horse power. The plant is of modern construction throughout, and the power for the entire works is obtained from water under pressure. The blowing engines for the Bessemer converters and other reciprocating appliances are operated by turbines; but the most interesting feature is the application of compressed air to the forging plant, which is the most powerful of its kind on the continent of Europe. In this department a 100 ton dead weight hammer and cranes capable of lifting and handling steel ingots weighing from 100 to 150 tons are operated by air under a pressure of 75 to 90 pounds per square inch. This power is generated in air compressors operated directly by water pressure, the mechanism consisting of three pairs of air cylinders 31½ inches in diameter, placed behind three pairs of water cylinders 14 inches in diameter, the stroke being 47¼ inches, a fly-wheel is connected with each pair of water cylinders.

The 100 ton hammer has a cylinder 6 feet 3½ inches in diameter and 16 feet 5 inches stroke, the air to operate it coming from the compressors described, the pressure being equalized by a series of syphons connected with a water tank.

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* **Minutes of Proceedings of the Institute of Civil Engineers, Vol. XCIII, Part III.**

The two large 100 and 150 ton cranes which are also operated by compressed air swing around the hammer in a circle 131 feet in diameter, the crabs traveling at a height of 75 feet above the floor.

We have in this country utilized water pressure engines on a comparatively small scale to raise water, as at Washington, D. C., and Ithaca, N. Y., but the engines at Terni complete a plant much larger than any in America. We also have an instance of a water pressure engine being used to operate an air cylinder for a blast furnace in Virginia. In the Lake Superior iron ore region the compressed air which operates the machinery of some of the larger mines is obtained from compressing cylinders driven by turbine wheels. In these cases the air is carried to the mines several miles from the compressors.

We believe there are localities in the United States where large powers can be cheaply developed by means similar to those employed at the Terni works in Italy, and trust that the brief epitome presented of the prominent features of this interesting plant may prove of value to some of our readers.

THE EDITOR.

THE Chandler mine, in Minnesota, twenty miles north-east of the well-known Tower mines, has begun shipping iron ore, and promises to become an important source for Bessemer ore. The management expect to ship between 40,000 and 50,000 tons of ore this season.

An analysis personally selected to represent the average of present workings showed:

Iron,	66.50
Phosphorus,	0.053
Silica,	2.62

Determinations of large samplings taken at a depth of 80 feet from the surface gave:

Iron,	66.23	68.73
Phosphorus,	0.058	0.05
Silica,	2.60	1.13

Comparison of the Pig Iron Statistics of Great Britain and of the United States.

In the annual report of the British iron trade, Mr. J. S. Jeans, the secretary, reports that the production of pig iron in Great Britain in 1887, was nearly 8.5 per cent. greater than in 1886, the figures being:

	Gross Tons.
Pig iron made in 1887, in Great Britain,	7,441,927
Pig iron made in 1886, in Great Britain,	6,870,665*
Increase,	571,262

As regards the descriptions of pig iron made in 1887, the following figures are believed to show approximate, though perhaps not entirely accurate, results:

	Gross Tons.
Forge and foundry,	3,672,390
Hematite,	3,064,837
Basic iron,	471,510
Spiegeleisen and ferromanganese,	233,190
Total,	7,441,927

The statement of the consumption of pig iron in 1887 is as follows:

Total production in 1887, in Great Britain,	7,441,927
Deduct increase of stocks at December 31, 1887, over 1886,	124,860
Consumption in 1887,	7,317,067
Consumption in 1886,	6,731,328
Increase in 1887,	585,739

We however question the propriety of estimating the consumption of pig iron in Great Britain by deducting augmented stocks from the production; for the export trade is no small factor, the quantities of British pig iron sent to all countries being as follows:

	Gross Tons.
Exports in 1886,	1,044,552
Exports in 1887,	1,159,500

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*Official government statistics give 7,009,754 gross tons.

This makes the home consumption of Great Britain,

	Gross Tons.
In 1886,	5,686,776
In 1887,	6,157,567

The exports of Great Britain also include large amounts of manufactured iron and steel. The total exports of *all kinds* of iron and steel to all countries being:

	Gross Tons.
In 1886,	3,388,494
In 1887,	4,146,907

The total stocks of British pig iron at the close of 1887 as compared with 1886, were as follows:

	1887. *Gross Tons.*	*1886.* *Gross Tons.*
Scotland,	1,228,040	1,183,039
Cleveland,	637,682	652,445
West Coast,	503,120	356,720
Other districts,	247,524	299,302
Total,	2,616,366	2,491,506

To properly appreciate these figures, we may compare them with the statistics of pig iron production in the United States, as compiled by the American Iron and Steel Association. 'Our production of pig iron in 1887 was about 13 per cent. greater than in 1886, the figures being:

	Gross Tons.
Pig iron made in 1887 in the United States,	6,417,148
Pig iron made in 1886 in the United States,	5,683,329
Increase,	733,819

The augmented output of the American blast furnaces in 1887, was therefore 162,557 gross tons in excess of that of the British furnaces; and our total production was but 1,024,779 gross tons below that of Great Britain, although but a few years ago we made scarcely one-half as much pig iron as our English cousins.

Separate statistics of forge and foundry pig irons are not collected in this country, but we produced in 1887 of

	Gross Tons.
Bessemer pig iron,	2,875,461
Speigeleisen and ferromanganese,	42,500
Leaving for forge, foundry and basic iron,	3,499,187
Total as above,	6,417,148

In estimating the apparent consumption of American pig iron, a factor must be taken into account, which does not enter into the computation of British pig iron consumption, viz: The importation of foreign pig metal. Mr. James M. Swank makes the following statement of the apparent consumption of pig iron in the United States in 1887.

	Gross Tons.
Total production in 1887 in United States, ...	6,417,148
Pig iron imported in 1887, ...	467,522
	6,884,670
Deduct increase of stocks December 31, 1887, over 1886, ...	76,284
Apparent consumption in 1887, ...	6,808,386
Apparent consumption in 1886, ...	6,191,354
Increase in 1887, ...	617,032

Basing a comparison therefore upon the more equitable basis of consumption, we find that in 1887, the apparent home consumption of pig iron in America was 650,819 gross tons greater than in Great Britain for the same year, and our increased consumption in 1887 over that of 1886, was 180,028 gross tons in excess of the advance shown by Great Britain.

The total stocks of American pig iron at the close of the years 1887 and 1886 were:

	1887.	*1886.*
Stock on hand, gross tons, ...	301,912	225,628

Great Britain, therefore, carried over from 1886, eleven times, and from 1887, nearly nine times as much pig iron as was in the hands of the American blast furnace proprietors at the dates named, while in round numbers British production was one million tons more and consumption of pig iron 650,000 tons less than that of the United States.*

The position of business at present writing, may be judged from the statistics for the first half of the year 1888, as published in the *Bulletin* of the American Iron and Steel Association. The figures therein presented show that during the first six months of the present year 3,020,092 gross tons of pig iron were produced, of which 1,178,508 gross tons were for the manufacture of Bessemer steel. The relative figures for the last six months of 1887 were: total pig iron made 3,367,853, or 347,761 more than in the first six months of 1888. The amount of Bessemer pig metal made in the last six months of 1887 was 1,561,061, or 382,553 more than in the first six months of 1888. We thus see that except in the demand of the steel rail mills we have made an advance over the product in both the first and the last half of 1887; and the decline of steel rail manufacture is but a temporary matter, which an advance in the demands will soon counteract. We have no corresponding figures for the same intervals for Great Britain, but introduce the statistics here for the information of our readers, and to assist in a thorough understanding of the relative position of two great iron producing countries.

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*In these calculations no account is made of the small quantities of pig iron imported into Great Britain or exported from the United States.

A brief resume of the above statistics, will we trust, place the American pig iron industry in its true position before our readers, and demonstrate how important it is, and how much of our national progress is dependent upon fostering it.

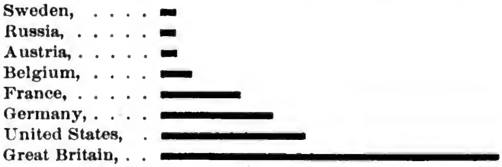
	Great Britain. Gross Tons.	*United States. Gross Tons.*
Pig iron made in 1887, ...	**7,441,927**	**6,417,148**
Increase over product of 1886,	**571,262**	**733,819**
Apparent home consumption of pig iron in 1887, ...	**6,157,567**	**6,808,386**
Increase over consumption of 1886, ...	**470,791**	**650,819**
Stocks of pig iron held over from 1887, ...	**2,616,366**	**301,912**
Increase of stocks since 1886,	**124,860**	**76,284**
Percentage of stock to production, ...	**35.2**	**4.7**

Our stocks of domestic pig iron held over from June, 1887, were 90,610 gross tons less than the foreign pig iron imported into the country during the year, demonstrating as we have before stated, the remarkable sensitiveness of the American pig iron industry to the demands of the home market. When we recall the necessity of providing by contract for supplies of fuel, ores and flux, long in advance of requirements, the filling of contracts for pig iron and the expense and inconvenience of putting a blast furnace in or out of blast, this close approximation to the demands of the country, demonstrate that the bug-bear of over-production so often referred to is not a reality. A glance at the stocks in hands of British blast furnaces explains why foreign pig iron so readily responds by increased importations to any advance in prices on this side of the water.

In discussing the progress of the American pig iron industry, the *Iron Age* compares the positions of the United States and other iron-producing nations in the years 1873 and 1886, as the figures for 1887 were not obtainable for all of the countries. From this article we excerpt the following:

"The production of the United States in 1873 was so far below that of Great Britain that it would have taken this country 133 weeks, or over two years and a half, to make as much pig iron as its overshadowing competitor did in one year. The production of Germany was so close to that of the United States that it would have required 41 weeks for this country to make as much as Germany did during the year. To produce as much as France turned out in a year would have required 28 weeks; Belgium, 13 weeks; Austria, 8 weeks; Russia, 7 weeks, and Sweden 6 weeks. Represented graphically, the position of the United States among the iron-producing countries of the world, taking the production of Sweden as the unit, was substantially as follows in 1873, only 14 years ago:

THE RANK OF PIG IRON PRODUCERS IN 1873.



In 1873 the production of Germany and Belgium exceeded that of the United States, while the production of Great Britain was far in excess of that of the whole continent of Europe. In that year Great Britain produced 86 per cent. as much pig iron as the other seven leading iron countries, but in 1886 it produced only 53 per cent. In 1873 the United States produced 22 per cent. as much as the other seven countries, while in 1886 it produced over 43 per cent. America has thus advanced while Great Britain has retrograded.

The average weekly production of these several countries in 1873 and 1886 forms an interesting table, and it is here reproduced:

AVERAGE WEEKLY PRODUCTION 1873 AND 1886.

Countries.	*1873.* *Tons.*	*1886.* *Tons.*
Great Britain,	126,278	132,128
United States.	49,249	109,123
Germany,	37,785	64,227
France,	26,557	28,997
Belgium,	12,549	14,122
Austria,	8,165	13,406
Russia,	6,808	10,000
Sweden,	6,192	8,937

The progress here shown by the United States surpasses that made by any other country, and the increase in productive capacity which is now under way on this side of the Atlantic is far in excess of the efforts being made in the same line in any other part of the world."

Coke Manufacture.

"We scarcely realize that as a coke producer, the United States took no position of importance, until after the close of the war of the rebellion, that beyond the use of the residual coke from gas retorts, the fuel was but little known, and that it has been within fifteen years that the Connellsville coke region has become prominent. The Connellsville *Tribune* states that the use of coke in iron production is claimed as early as 1817, but that the first authentic record of coke making as a business dates back to 1841. A year later this two oven plant was leased and two boat loads of coke, aggregating about 13,000 bushels, were sold in Cincinnati, at seven cents a bushel. Between this time and 1860, three more ovens were built. In 1860 the Fayette works of thirty ovens were constructed, and in 1864, the Jackson works of forty ovens was added. These several plants, together with 140 ovens, near Dunbar, aggregating about 300 ovens, comprised all the works in the region.

"The work of building ovens took a boom in 1872, and in 1876 there were 3,000 ovens in the region. Three years later they had increased to 4,000. Then came a sudden and unprecedented demand. Coke rose to fabulous prices, and fortunes were made in a few months. This gave an impetus to the business which has continued without entire abatement, sometimes under the most trying circumstances to the present day. To illustrate the steady growth of the industry, it might be added that the three years following 1879 more than doubled the number of ovens in the region, the aggregate in 1882 being 8,400 against 4,000 in 1879. From 1882 to the present date, a period of six years, some of which have been years of severe depression, the number of ovens has increased steadily at the rate of nearly 800 per year, the aggregate now being 13,047, strung along the hills and valleys of the region from near Latrobe, Pa., on the north, almost to Morgantown, W. Va., on the south, a distance of fifty miles.

NOTE.—In the mineral resources of the United States, 1886, Mr. Jos. D. Weeks gives a description of the manufacture of coke, he says, that the total amount of coke produced in 1886 in the 22,597 ovens which were then built, was 6,845,309 net tons, 10,688,972 net tons of coal being treated. Of this amount 4,180,521 net tons were made in the Connellsville region and 442,968 tons in the Upper Connellsville district.

◆

FROM the reports of the British Inspectors of Mines for the year 1887, recently issued, we learn that during last year the aggregate number of persons employed in and about the whole of the mines in the United Kingdom of Great Britain and Ireland amounted to 568,026. The summary of the quantities and kinds of mineral wrought in the different districts shows that the total quantity was 173,049,795 tons, of which 162,119,812 were coal and 7,569,918 iron ore, the rest being fire-clay, oil shale and other minerals, being a total increase of 3,042,836 tons, compared with the preceding year, the increase of coal being 4,601,330, with a decrease of iron ore of 1,292,730 tons.

Imports of Iron and Steel for Four Years.

The following table will exhibit the amounts of each class of material specified which were imported into the United States from foreign countries during the fiscal years ending June 30th, 1885, 1886, 1887 and 1888.

IRON AND STEEL IMPORTED.

ARTICLE—GROSS TONS.	YEAR ENDING JUNE 30TH.			
	1885.	1886.	1887.	1888.
Pig iron,	151,959	261,674	418,819	325,517
Scrap iron,	19,841	49,220	245,755	142,087
Scrap steel,	4,318	4,278	26,012	13,019
Bar iron,	32,756	33,515	33,514	33,198
Iron rails,	26	31	17	225
Steel rails,	4,177	10,476	77,026	136,799
Cotton-ties,	17,006	16,107	12,606	19,061
Hoop and scroll iron,	336	113	23	9
Steel plates, etc.,	1,074	3,154	15,709	22,421
Steel blooms, etc.,	19,016	64,409	285,437	185,040
Sheet and plate iron,	6,054	6,153	6,729	7,300
Tinplates,	226,408	255,470	255,456	283,457
Wire rods,	115,866	135,529	143,991	120,955
Wire and wire rope,	1,716	2,604	2,176	3,172
Anvils, forgings, etc.,	621	843	1,068	1,298
Chains,	620	571	718	922
Total iron and steel,	601,794	844,147	1,525,056	1,294,480
Iron ore,	425,870	701,243	1,141,774	919,644

Of the total quantity of iron and steel imported in the fiscal year ended June 30, 1888, namely, 1,294,480 gross tons, 474,346 tons were imported in the first six months of the calendar year 1888 and the remainder, 820,134 tons, in the last half of 1887.

During the first six months of the calendar year 1888 our imports of pig iron amounted to 99,753 gross tons; scrap iron, 29,400 tons; steel rails, 44,573 tons; steel plates, sheets, strips, etc., 11,309 tons; steel blooms, slabs, billets, etc., 56,098 tons; tinplates, 145,337 tons; and wire rods, 60,813 tons.

The foreign value of our iron and steel imports in the fiscal year 1888, including machinery, cutlery, fire-arms, etc., was $48,992,022, against $49,203,164 in the fiscal year 1887.—*Bulletin.*

Our Mineral Resources.

In the summing up the estimated value of all the mineral products of the United States in 1887, Mr. David T. Day, Chief of Division of Mining Statistics and Technology of the United States Geological Survey, says that it amounts to $538,056,345, and that "this is the largest total ever reached by the mineral industries of any country. It is nearly $73,000,000 more than the product of the United States in 1886 and considerably more than $100,000,000 in the excess of the year 1885."

The quanties and values of some of the more important metallic and non-metallic products are arranged in the following table in an order of prominence based upon the money value; the figures given for non-metallic products are spot values.

SOME MINERAL PRODUCTS OF THE UNITED STATES IN 1887.

	Quantity.	Value.
Pig-iron, spot value, . . . long tons .	6,417,148	$121,925,800
Bituminous coal, . . . do. . .	78,426,214	97,939,656
Pennsylvania anthracite, . . . do. . .	37,578,747	84,552,181
Silver, coining value, . . . troy ounces .	41,269,240	53,441,300
Gold, coining value, . . . do. . .	1,596,500	33,100,000
Building stone, . . .	. . . .	25,000,000
Lime, . . . barrels .	46,750,000	23,375,000
Copper, value at New York City, . . pounds .	184,670,524	21,052,440
Petroleum, . . . barrels .	28,249,543	16,949,726
Lead, value at New York City, . . short tons .	160,700	14,463,000
Natural gas, . . .	. . . .	13,582,500
Cement, . . . barrels .	6,692,744	5,186,877
Zinc, value at New York City, . . short tons .	50,340	4,782,300
Salt, . . . barrels .	7,831,962	4,093,846
Limestone for iron flux, . . . long tons .	5,377,000	3,226,200
South Carolina phosphate rock . . . do. . .	480,558	1,836,818
Zinc-white, . . . short tons .	18,000	1,440,000
Quicksilver, value at San Francisco, . . flasks .	33,825	1,429,000
Nickel, value at Philadelphia, . . . pounds .	205,556	133,200
Antimony, value at San Francisco, short tons .	75	15,500
Asbestos, . . . do. . .	150	4,500
Platinum, value (crude) at New York City, . . . troy ounces .	448	1,838
Borax, . . . pounds .	11,000,000	550,000
Gypsum, . . . short tons .	95,000	425,000
Manganese ore, . . . long tons .	34,524	333,844
Mineral paints, . . . do. . .	20,000	310,000
Pyrites, . . . do. . .	52,500	210,000
Flint, . . . do. . .	32,000	185,000
Mica, . . . pounds .	70,500	142,250
Corundum, . . . short tons, .	600	108,000
Sulphur, . . . do. . .	3,000	100,000
Chrome iron ore, . . . long tons .	3,000	40,000
Graphite, . . . pounds .	416,000	34,000

Concerning some of the, to our readers, most important products, we quote from Mr. Day's summary.

Iron.—The principal statistics for 1887 were: Domestic iron ore consumed, about 11,300,000 gross tons; value at mines, $33,900,000. This is an increase over 1886 of 1,300,000 tons in quantity and $5,900,000 in value. Imported iron ore consumed, 1,194,301 gross tons; total iron ore consumed in 1887, about 12,494,301 gross tons, or 1,454,868 tons more than in 1886. Pig iron made, 6,417,148 gross tons; value at furnace, $121.925,800. This is an increase over 1886 of 733,819 tons in quantity and $26,730,040 in value. Steel of all kinds produced, 3,339,071 gross tons, an increase of 776,569 tons over 1886; value at works, $103,811,000. Total spot value of all iron and steel in the first stage of manufacture, excluding all duplications, $171,103,000, an increase of $28,603,000, as compared with 1886. Limestone, used as flux in the manufacture of pig iron in 1887, about 5,377,000 gross tons; value at quarry, about $3,225,200.

Coal.—The total production of all kinds commercial coal in 1887 was 123,965,255 net tons (increase over 1886, 16,283,046 tons), valued at the mines at $173,530,996 (increase, $26,418,241).

Coke.—The total production of coke in the United States for the year ending December 31, 1887, was 7,857,487 net tons, valued at $15,723,574. This is the greatest product ever reached in the United States, being 1,022,419 tons greater than in 1886.

Manganese.—The total production of manganese ore in the year ending December 31, 1887, was 34,524 gross tons, valued at $333,844. The production of manganiferous iron ore was 211,751 tons, valued at $600,000.

Petroleum.—Total production, 28,249,543 barrels of 42 gallons each. The total value, at an average of 60 cents, was $16,849,726. The increase over 1886 was very slight, only 139,428 barrels. There was a decrease of 11¼ cents per barrel in the average price.

Natural Gas.—The production of natural gas in the United States in 1887 was equivalent to 9,055,000 net tons of coal displaced. This, at an average value of $1.50 a ton, would make the value of the coal displaced by natural gas (which is the measure of the value of the gas), $13,582,500. In 1886 the corresponding quantity was 6,353,000 tons, worth $9,847,150.

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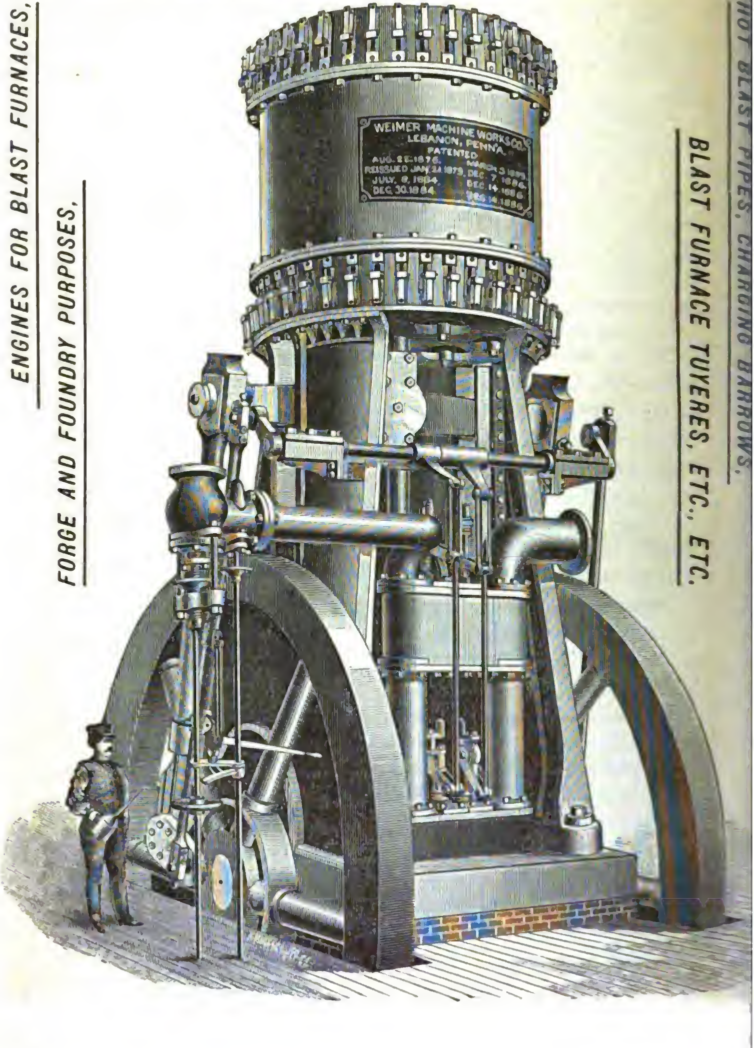

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The favor with which the JOURNAL is received is exhibited by increased subscriptions and by an unexpected demand for back numbers. This is gratifying to the proprietors and editor and offers encouragement to renewed efforts to place the publication in position to command the confidence and patronage of those interested in iron and steel production and manufacture. An apology for delay in issuing the present number is due our readers, but circumstances beyond our control made it necessary to defer the publication beyond the regular interval, and a purpose of completing the volume at a set time caused further postponement. We expect to have future numbers appear regularly.

THE EDITOR.

Calculation of the Ore Mixture or Burden for a Blast Furnace.

[Translated from the German of Prof. Ledebur for the JOURNAL OF THE UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS, by E. K. Landis, B. S.]

As the production of any desired iron is closely connected with the temperature of formation and the melting point of the accompanying slag, the first task in the production of the iron must be to so proportion the burden as to produce a slag of corresponding properties, *i. e.*, of correct chemical composition. This object is attained in an empirical way by melting different experimental mixtures– which is best done in a crucible—until the desired result is obtained. A shorter method is by calculation—stoichiometrically or by atomic weights.

In order to employ the latter method one must clearly know which composition of slag is most suitable for the production of the kind of iron to be made, under the conditions given, whether coke or charcoal is used, high or low heats of blast, etc. Authentic analyses of furnace slags which have been produced under known conditions must form the basis of calculation in all these cases when one tries to form the burden in such a way that the slag produced may resemble one of the normal slags chosen. Owing to the great number of elements in a blast furnace slag and the multiplicity of composition of the materials smelted, it is not always feasible, from the ores and fluxes at hand, to calculate a burden whose composition in all parts will conform exactly to that of a given normal slag, so it suffices to form a slag which at least essentially, will show a fusibility corresponding to the requirements of the case. Here comes in before everything else the ratio of silica to the bases, in the second place the ratio of alumina to the stronger bases (CaO, MgO), finally also whenever feasible, the inverse ratio of the last two named bases. In practice it is frequently observed that this inverse ratio of CaO to MgO (lime to magnesia) is by no means equal for the fusibility of the slag; a slag high in MgO and low in CaO is, for the same oxygen ratio, generally less fluid than in the reverse case. In the calculation, not only the composition of the slag, but also its amount in proportion to the iron made and the amount of iron in the mixture are to be considered. The larger the amount of slag the more heat is consumed in melting it, and that much more fuel must be used to produce this heat. The less the amount of slag the quicker its composition is altered by irregularities in the working of the furnace. the more easily the furnace is affected, and the more readily unreduced ore is produced. A blast furnace without slag is inconceivable. In general it is easier to make white iron with a burden containing little slag, than to make grey iron or spiegel-eisen. It is seldom that one is forced to give a corresponding flux entirely by increasing the amount of slag.

At the Styrian and Carinthian Iron Works, which produce white iron from easily reducible ores with charcoal, the proportion of slag to iron sometimes is not much more than 0.6 to 1: at the Cleveland furnaces, making a coke foundry iron, the ratio is 1.5: 1 and sometimes rises to 2: 1. A larger amount of slag than in the last case increases the fuel consumption to such an extent that only exceptionally can a blast be made to pay.

The amount of iron in the ore stands in close relation to the amount of slag; in most cases this varies between 25 and 40 per cent: at some of the furnaces mentioned in the Alps it sometimes rises to 50 per cent. With the low yield of 25 per cent., on the other hand, it is only possible under very favorable conditions to make a paying blast.* As an aid in the task of calculating from given ores and fluxes a burden which shall produce a slag of the desired composition, and whose amount shall come within the required limits, several propositions have been made. The following method, one of Mrazac's, seems the most suitable for practical purposes.

From the chemical composition of the ores and fluxes, and also the coke ash, determined by average analyses as a base, a table is constructed which possesses the following arrangement:

---

*An unusual yield of 50 per cent. will seem to our American blast furnace managers indicative of lean ores, and we fancy few of them would undertake, even under "favorable conditions," to "make a paying blast" with ores yielding 25 per cent. of iron. It is, however, to those who have overcome disadvantages that the iron industry is indebted for its progress, and the results shown by Professor Ledebur will serve as a guide for those who are favored with richer ores.—The EDITOR.

STOICHIOMETRIC ORE AND FLUX TABLE.

ORES, FLUXES, ETC.	SLAG FORMING CONSTITUENTS.						Fe.	OXYGEN IN SLAG FORMING CONSTITUENTS.					
	MnO.	CaO.	MgO.	Al_2O_3.	SiO_2.	Sum.		MnO.	CaO.	MgO.	Al_2O_3.	B.	S.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Oolitic limonite.													
Lias ore,	.007	...	....	.065	.156	.228	.428	.0016	...	..	.0305	.0321	.0832
Spathic ore,	.023	.159	.085	....	.011	.278	.226	.0051	.0454	.034	....	.0845	.0059
Bog ore,	.003	.012	....	.010	.095	.120	.403	.0007	.0034	....	.0047	.0088	.0506
Limestone,	....	.518	....	....	.021	.539	....	....	.1480	....	....	.1480	.0112
Coke ash,	....	.200	....	.150	.500	.850	.100	....	.0571	....	.0705	.1276	.2664

STOICHIOMETRIC ORE AND FLUX TABLE—*Continued.*

ORES, FLUXES, ETC.	EXCESS OF OXYGEN OVER THAT REQUIRED TO FORM				STOICHIOMETRIC EQUIVALENTS. Amount of ore required to bring in one part of oxygen for			
	Singulo silicate slag.		Bi-silicate slag.		Singulo silicate slag.		Bi-silicate slag.	
	b. *Bases.*	*s.* *Acid.*	*b.* *Bases.*	*s.* *Acid.*	1-*b.*	1-*s.*	1-*b.*	1-*s.*
	14.	15.	16.	17.	18.	19.	20.	21.
Oolitic limonite.								
Lias ore,		.0511		.0190		19.59		52.62
Spathic ore,	.0786		.0815		12.72		12.27	
Bog ore,		.0418		.0330		23.92		30.30
Limestone,	.1368		.1424		7.31		7.02	
Coke ash,		.1388		.0112		7.20		89.28

Columns 1 to 5 give the amount of slag forming constituents contained in one part of ore, flux and coke ash. It is to be expected that other constituents than iron may be reduced, for example a part of the manganese and silicon, and these must be regarded; in most cases we come sufficiently near the truth if we assume that one-half of the manganese is slagged off, and the rest reduced. The reduction to silicon can be neglected in making white iron; for gray iron it is assumed that an amount of silica corresponding to one-twenty-fifth, the amount of iron in the ore [equal to about 2 per cent. in the pig] will be reduced. If the amount of slag is considerable, the reduction to silicon may be neglected, as the whole calculation, by reason of unknown reactions taking place in the furnace [volatilization of different bodies in the form of chlorides, cyanides, sulphides and the unreduced iron remaining in the slag] only shows an approximate result, which must be corrected later by practical investigation.

Column 6 contains the sum of all the slag-forming constituents.

Column 7 shows the amount of iron [which by the reduction of considerable amounts of manganese will be increased to that extent]. Both columns will facilitate later, a short inquiry into the proportion between slag and iron in a burden to be calculated, as well as the amount of iron in it

In columns 8 to 13 follow the oxygen contents of the amounts of individual bodies represented in columns 1 to 5. An addition of the figures contained in columns 8 to 11 gives the figures for column 12, i. e. the whole of the oxygen appearing in the bases [denoted by B] while column 13 gives the oxygen of the silica. The proportion S divided by B evidently gives the oxygen ration of the ores, fluxes, etc., under consideration. From this we can calculate, in a very simple manner, the figures for columns 14 to 17 which give the excess of oxygen, that either the bases or the silica under consideration contains, whenever it is desired to form one of the above mentioned silicates. In the table given as an example, the calculations for singulo and bi-silicates are both carried out, with the same facility those for sub-silicate, $\frac{4}{3}$ silicate, and any other silicate according to the composition of the slag to be formed, can also be carried out.

In the Lias ore represented in No. 1 for example, by column 12 the oxygen of the bases amounts to 0.0321, and by column 13 the oxygen of the silica amounts to 0.0832 parts in one part of the ore. In constructing a singulo-silicate slag, in which the oxygen of the bases equals the oxygen of the silica, the ore possesses an excess of acid oxygen 0.0832—0.0321 equals 0.0511 parts; these figures are given in column 15. On the other hand, if a bi-silicate slag is to be formed, in which the oxygen of the silica is twice that of the bases, then for 0.0321 parts of basic oxygen, (2 × 0.0321 equals 0.0642 parts of acid oxygen are required) there is also even now, an excess of acid oxygen, viz., 0.0832—0 0642 equals 0.0190 parts present [column 17].

If we denote [as already shown in the table] the figures of column 12 in general by B and those of column 13 by S. those of column 14 or 16 by *b* and those of column 15 or 17 by *s* we will have

For $\frac{2}{3}$ silicate, ...	$b = B - 1\frac{1}{2}\,S$ $s = S - \frac{2}{3}\,B$
For singulo silicate, ...	$b = B - S$ $s = S - B$
For $\frac{4}{3}$ silicate, ...	$b = B - \frac{3}{4}\,S$ $s = S - \frac{4}{3}\,B$
For bi-silicate, ...	$b = B - \frac{1}{2}\,S$ $s = S - 2\,B$

In general to form a silicate in which the ratio of the oxygen of the silica to that of the bases equals "n."

$$b = B - \frac{1}{n}\,S$$
$$s = S - n\,B$$

The reciprocal values of the figures mentioned above give, by a simple division, the figures in columns 18 to 21. They show how many parts of the ores, fluxes, etc., are necessary to bring into the burden one part of oxygen above that necessary to form a singulo-silicate, bisilicate, etc. If one part of the ore contains *b* parts of basic oxygen more than is required to form one of the above mentioned silicates, one evidently will employ $\frac{1}{b}$ parts of the ore under consideration in order to bring one part of the excess of basic oxygen into the burden. The same relation exists when the ore contains an excess of acid oxygen, instead of basic oxygen.

The lias ore No. 1 contains, for the formation of a singulo-silicate, in one part of ore, 0.0511 parts of acid oxygen; to bring in one part of this excess of oxygen $\frac{1}{0.0511}$ equals 19.59 parts of ore are required [column 19].

The figures of those columns denoted in the heading as Stoichiometric equivalents evidently show the amounts of ore, flux, etc., necessary to bring an equal amount of oxygen into the burden, for the composition of a desired silicate. All figures given in the same column are equal to each other in regard to slag forming. They show how much of an ore, flux, etc., is necessary to mix with another without causing an alteration in the oxygen ratio of the slag produced.

Each basic equivalent gives, with as many acid equivalents as the oxygen ratio of the slag to be formed requires, a slag of the desired oxygen ratio. For singulo silicate slags each basic equivalent must be combined with one acid equivalent; [columns 18–19] for bisilicate slags each basic with two acid equivalents [columns 20–21]. The table shows for example that it is possible to form a singulo or bisilicate slag from ores Nos. 1 and 2 without the use of any flux. In both cases Lias ore No. 1 acts as an acid equivalent, and Spathic ore No. 2 as a basic equivalent. To form a singulo silicate slag one equivalent or 19.59 parts of lias ore, is mixed with 12.72 parts or one equivalent of spathic ore.

Example.

19.59 parts lias ore contain of basic oxygen
19.59 × 0.0321= . . . . 0.629 parts.
12.72 parts of spathic ore.
12.72 × 0.0845= . . . . 1.075 parts.
1.704 parts.

19.59 parts lias ore contains of acid oxygen
19.59 × 0.0832, ... 1.629 parts.
12.72 parts spathic ore.
12.72 × 0.0059, ... 0.075 parts.
1.704 parts.

To form a bisilicate two equivalents or 2 × 52.62 equals 105.24 parts of lias ore, are mixed with 12.27 parts of spathic ore.

Example.

105.24 part lias ore contains of basic oxygen
105.24 × 0.0321, ... 3.378 parts.
12.27 parts spathic ore.
12.27 × 0.0845, ... 1.036 parts.
4.414 parts.

105.24 parts lias ore contain of acid oxygen 105.24 × 0.0832,	8.756 parts.
12.27 parts spathic ore 12.27 × 0.0059,	0.072 parts.
	8.828 parts.

Since the composition of the individual ores is known, and in respect to the slag forming constituents, is given in columns 1-5, it is easy to calculate the whole composition of the slag if the burden has been made in the manner mentioned above. A singulo silicate slag from 19.59 parts of lias ore and 12.72 parts of spathic ore, for example would contain

MnO from lias ore,	19.59 × 0.007	0.137	0.429 parts.
MnO from spathic ore,	12.72 × 0.023	0.292	
CaO from lias ore,	19.59 × 0.000		
CaO from spathic ore,	12.72 × 0.159		2.022 parts.
MgO from lias ore,	19.59 × 0.000		
MgO from spathic ore,	12.72 × 0.085		1.081 parts.
Al_2O_3 from lias ore,	19.59 × 0.065		1.273 parts.
Al_2O_3 from spathic ore,	12.72 × 0.000		
SiO_2 from lias ore,	19.59 × 0.156	3.057	3.196 parts.
SiO_2 from spathic ore,	12.72 × 0.011	0.139	
			8.001 parts.

32.31 parts of this burden would contain about 8.001 parts of slag whose percentage composition can now be calculated without difficulty. If only the total amount of slag is desired, not its composition, a shorter method would be to use the figures given in column 6:

The proportion of Al_2O_3 to the other bases in the slag is 1.273: 3.532 equals 1: 2.7 The amount of iron in the mixture would be [column 7]

19.59×0.428	8.384
12.72×0.226	2.874

32.31 parts contain 11.258 parts iron equal 34.8 per cent.

The amount of pig-iron, on account of the carbon contained in it, would reach a higher figure—about 36 per cent. The proportion of slag to iron is 8.001: 11.258: 0.7: 1 which is a favorable showing for work.

If a fuel is used for smelting which contains a large amount of ash, this must be considered in the calculation. This can be done in the following way. The amount of ash as well as its chemical composition is ascertained, and this last is put in the table along with the other constituents of the burden [see table given above]. Now suppose that for smelting 100 kilogr. of ore and flux, the necessary fuel composition will be from 30 to 40 kilogr., on the average 35 kilogr., and we can calculate from this the fuel necessary to smelt the amount of ore and flux in the burden calculated, and then it only remains to find from the table the amount of ore or flux of opposite composition necessary to flux it.

Suppose, for example, we intended to smelt the above burden of 19.59 parts lias ore and 12.72 parts spathic ore, calculated for a singulo-silicate slag, with coke containing 10 per cent. of ash, and of the chemical composition given under No. 5 of the above table. 32.31 parts of burden will require for smelting 12 kilos of coke which contain 1.2 kilos ash. To form a singulo silicate 7.02 parts coke ash equal one acid equivalent. [Column 19.] Therefore $\frac{1.2}{7.02} \doteq$ one-sixth basic equivalent required to flux the coke ash; if spathic ore is taken for this purpose then 12.72÷6=2.12 parts more than was used before must be taken for the burden, which will now consist of

19.59 parts lias ore.
14.84 parts spathic ore.

Should it not be deemed judicious to flux the coke ash by altering the amount of spathic ore, but by the addition of limestone of the chemical composition given under No. 4, then its equivalent for singulo silicate slag forming (7.31) is 7.31÷6=1.22 parts of limestone to be added to the mixture.

In the same way as in the example given above of a mixture containing only two ores, a burden can be composed of as many ores and fluxes as one chooses, as long as the rule is followed, "that the sum total of the acid equivalents to the sum total of the basic equivalents is in the ratio required by the oxygen ratio of the slag to be formed." Each basic equivalent must be combined for a singulo-silicate with one, for a bi-silicate with two, for a two-thirds silicate with two-thirds acid equivalent. If an excess of basic, or of acid material is to be smelted, then a suitable proportion must be arranged, according to its peculiar properties. Here also regard must be had to the different amount of Al_2O_3 each contains, that this is neither too high or too low, or the slag will be less fluid, and it is therefore desirable to have its proportion to the other bases in conformity with the normal slag chosen; the same is the case with regard to the proportion between CaO and MgO. Then the amount of iron in the burden under calculation comes into consideration, as well as the ratio of slag to iron; also the quantity of foreign constituents, phosphorus, manganese and sometimes sulphur, which the pig-iron would take up from one or the other of the ores, and which would influence its properties. Finally the relative cost of the individual ores and fluxes should not be passed over, as the cost of the pig-iron often depends upon this point.

Suppose it was required from lias ore No. 1 and bog ore No. 3 and limestone flux to calculate a burden giving a bi-silicate slag with a ratio of Al_2O_3 : [CaO, MgO]=$\frac{1}{4}$ or $\frac{1}{3}$. Should it prove judicious a corresponding amount of spathic ore might be used instead.

To form a bi-silicate each basic equivalent must be opposed to two acid equivalents. In the above mentioned case, as shown in columns 20–21, the lias ore and bog ore act as acid equivalents, and the limestone and spathic ore as basic equivalents. Without the addition of one of the two last mentioned materials, the smelting of the lias ore and bog ore with the formation of a bi-silicate slag could not be done.

First, if we take experimentally a mixture without spathic ore and with one equivalent of each of the other ores, we shall have

1. Equivalent lias ore, ...	52.62
1. Equivalent bog ore, ...	30.30
2. Equivalents.	
1. Equivalent limestone, ...	7.02
	89.94

The amount of Al_2O_3 on the one hand, as well as [CaOMgO] on the other hand in this burden will be:

	Al_2O_3	CaOMgO
52.62 parts lias ore contain, ...	3.42	. . .
30.30 parts bog ore contain, ...	0.30	0.36
7.02 parts limestone contain, ...	. .	3.63
	3.72	3.99

The ratio of Al_2O_3 : (CaOMgO) is too great. The amount of lias ore must be considerably diminished and that of the bog ore raised. If we take only 0.2 equivalents of the first, then we shall have

		Al_2O_3	CaOMgO
0.2 equivalents lias ore, . . .	10.52 parts with	0.68	. .
1.8 equivalents bog ore, . . .	54.54 parts with	0.54	0.65
2 equivalents.			
1 equivalents limestone, .	7.02 parts with	. .	3.63
	72.03	1.22	4.28

and this ratio will be diminished to 1 : 3.5. The amount of iron in the last mixture would be:

10.52 parts lias ore contain of iron, . . .	4.50	parts.	
54.54 parts bog ore contain of iron, . .	21.97	parts.	
7.02 parts limestone contain of iron, . . .		parts.	
72.08 parts contain of iron, ...	26.47		= 36.7 per cent.

With regard to the percentage of carbon, an output of about 38 per cent. of iron is to be expected, and the mixture in this respect would be worth smelting, without requiring an increase in the amount of iron by substituting spathic ore for limestone. Another occasion for this might arise from the fact that both lias ore and bog ore are high in phosphorus, and a smaller amount of phosphorus would appear to be necessary or desirable Lias ore contains 0.5 per cent. of phosphorus, and bog ore 1.02. If we suppose that this is all taken up by the iron, which is at least approximately the case, the amount of phosphorus in the iron would be

10.52 parts lias ore contain of phosphorus, ...	.052 parts.
54.54 parts bog ore contain of phosphorus, ...	.654 parts.
	.706 parts.

These .706 parts phosphorus would be taken up by 26.47 parts of iron, which the above calculation shows to be contained in the ores. The amount of phosphorus in the iron would therefore be about 2.6 per cent. The spathic ore is free from phosphorus. Replacing experimentally the entire amount of limestone flux by an equivalent quantity of spathic ore, the amount of iron in the burden is increased, and in this way the amount of phosphorus in the iron produced is diminished. We then obtain the following new mixture :

	Al_2O_3	CaOMgO	Fe.	P.
0.2 equivalent lias ore, 10.52 parts with .	0.68	. . .	4.50	0.052
1.8 equivalent bog ore, 54.54 parts with .	0.54	0.65	21.97	0.654
1.0 equivalent spathic ore, ... 12.27 parts with .	. .	2.99	2.77	. . .
Total, ... 77.33 parts with .	1.22	3.64	29.24	0.706

Ratio of Al_2O_3 ; [CaOMgO] 1 : 3
Amount of iron in mixture 37.8 per cent.
Amount of phosphorus in iron 2.4 per cent.

In this case the amount of phosphorus is not considerably diminished.

Then comes the question what relation the costs of the two mixtures bear to each other. An equality in this respect is only possible if we consider these costs not according to the unit of weight of the mixture, but the unit of iron contained in the mixture. For example let the cost of the different ores, including transportation to the furnace, be as follows:*

1,000 kilos lias ore, ...	9 marks.
1,000 kilos bog ore, ...	6 marks.
1,000 kilos spathic ore, ...	8 marks.
1,000 kilos limestone, ...	4 marks.

then the cost of burden first calculated without spathic ore would be:

10.52 parts lias ore with	4.50 parts iron,	0.095 marks.
54.54 parts bog ore with	21.97 parts iron,	0.327 marks.
7.02 parts limestone with	. . . parts iron,	0.028 marks.
	26.47 parts iron	0.450 marks.

If 26.47 kilos cost 0.45 mark 1000 kilos 17 marks.

The cost of the second burden with spathic ore would be:

10.52 parts lias ore with	4.50 parts iron,	0.095
54.54 parts bog ore with	21.97 parts iron,	0.327
12.27 parts spathic ore	2.77 parts iron,	0.098
	29.24 parts iron,	0.520

Therefore 1,000 kilos would cost 17 marks 78 pfennig, or 78 pfennig more than the other high phosphorus burden, but the

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*These figures are only assumptions, but apparently are intended to represent fair averages. Assuming that 1,000 kilogrammes, or one metric ton, as practically equivalent to one gross ton, and one mark equal to 24 cents, we will have the following values:

1 gross ton lias ore, ...	$2 16
1 gross ton bog ore, ...	1 44
1 gross ton spathic ore, ...	2 00
1 gross ton limestone, ...	96

—EDITOR.

iron produced will be worth more. In this case the employment of spathic ore is advantageous.

If the smelting is to be done with coke it is judicious, as in the example previously given, to consider its amount of ash. If we again allow a coke consumption of 35 kilos per 100 kilos of burden smelted, and an amount of ash of 10 per cent. of the composition given in the table, then in smelting the burden first calculated for 72.08 parts about 24 parts of coke with 2.4 parts of ash will be required. As the equivalent of the coke ash for a bi-silicate = 89.28, then 2.4 parts correspond to about $\frac{1}{37}$ equivalent, and requires for fluxing $\frac{1}{74}$ basic equivalent; by using limestone about $\frac{1}{10}$ equivalent will be necessary, which is added to the 7.02 parts already at hand.

If we desire to calculate the entire composition of the slag we have the following:

	MnO	CaO	Al_2O_3	SiO_2	Total.
10.52 part lias ore give . .	0.07	. .	0.68	1.64	2.39
54.54 part bog ore give . .	0.16	0.64	0.54	5.18	6.52
7.12 part limestone give	. .	3.69	. .	0.15	3.79
2.40 part ash give	. .	0.48	0.36	1.20	2.04
	0.23	4.81	1.58	8.17	14.79
Or in 100 parts, ...	1.56	32.29	10.73	55.42	100.00

When a table of this kind has once been calculated for all the materials to be smelted, as in the example given above, a burden can be calculated in a short time for a slag of any of the compositions mentioned, or when the properties of the ores to be mixed renders it impossible to form one or the other of the slags, the table shows the reason why.

A variation of the mixture at hand can be made by the help of this table, as easily as the calculation of a new one, when for example an ore gives out, when a new ore is to be introduced into the mixture, when the phosphorus is to be diminished or the manganese increased, etc., etc. In practice this case occurs oftener than the calculation of a new burden, and the solution of the question is the easier, because here generally a slag of known composition is at hand, and it only remains to alter the composition of the burden without causing an important alteration in the composition of the slag. In all these cases the oxygen ratio of the slag remains the same, as long as the different ores and fluxes are opposed in the proportions by weight in which their stoichiometrical equivalents stand to each other. 19.59 parts lias ore are for a singulo silicate, as column 19 of the above given table shows at a glance, equal to 23.92 parts of bog ore; if a mixture containing 25 parts lias ore is to be replaced by bog ore then $\frac{23.92}{19.59}$ 25=30.5 parts of the latter ore will be required. The oxygen ratio of the slag will in this case remain unaltered; the amount of Al^2O^3 in the mixture, however, as is easily seen, will be reduced by the substitution of bog ore for lias ore. If it is desired to increase this, then the addition of some aluminous material, such as clay slate, is necessary, and as soon as its composition and equivalent are ascertained, the table shows at a glance how to make the change.

[This paper is more technical than those which generally appear in the JOURNAL, but we think it is sufficiently explicit to be appreciated by most of those interested in the practical management of blast furnaces for whose information its translation and publication were made. The importance of proper fluxing, and the relation which it bears to satisfactory blast furnace operations, is now generally appreciated, and we believe that the above contribution to metallurgical literature will be welcomed by those who have the practical direction of the blast furnace industry. Mr. Landis made no attempt in his translation to introduce other ores than those given by Ledebur, or to employ other units or values than given in the original, the purpose being to present the method rather than a local application.—The EDITOR.]

◆

Using Machinery in the Forests.

The ingenuity displayed by inventors and the experimental work which has been devoted to improvements in tree felling, log transportation, etc., is beyond what is generally appreciated, and an examination of the model room of the United States patent office will show how thoroughly the ground has been covered. The majority of these inventions, like patents of other specialties, of course, have never been practically applied, and others have had only an empirical existence. Whether the arrangements described below will belong to one or the other of these classes we cannot assert, but attention having been directed to several new features, we present them as of interest to such of our readers as own or control woodland.

The first is a steam logging sled which is in operation in northern New York, and which can be adapted for handling logs or cord wood. It is described as a large box car on bobs or runners, and is intended to haul the logs out of the woods on the snow. A clipping sent us states "the sleigh is eight feet high, and the bobs six feet wide. The motive power is supplied by a boiler seven feet high which weighs 8,000 pounds and two high pressure engines weighing 5,500 pounds. There are four drive wheels which weigh 4,000 pounds, and are driven by an endless chain from the engine. The sleigh is steered somewhat after the manner of a steamboat. The drive wheels are covered for about three-fourths of their circumference by a steam-box into which the steam exhausts; the water falling into the track of the sleigh, freezes and thus makes a road of solid ice. To prevent the drive wheels from slipping, these are supplied with spurs three inches deep and ten inches long. The sleigh is capable of carrying 15,000 feet of logs at one time, which is equivalent to the amount that would ordinarily be drawn by fifteen teams of horses. The sleigh is used in drawing logs from the woods to the banking ground."

The second invention to which our attention was directed is an electric tree-felling machine, which is illustrated and described in the *Engineering and Mining Journal*, and from it we extract the following:

"Hitherto the only mechanical appliance to supersede hand labor in the felling of trees has been the steam tree feller, but the employment of steam for such a purpose is coupled with considerable difficulties. Not only is it necessary to place the boiler in close proximity to the tree that is to be felled, but the weight of the machine itself is considerable, and its application when the ground is uneven inconvenient. In a dense forest, machinery of this description can only be used when the tree to be felled is either on the borders of the forest or in a clearance accessible by a road over which the boiler can be transported. These difficulties are greatly minimized, if not entirely overcome, by the application of electricity. The source of power in this case is not a boiler, which must be placed near the tree, but some prime mover and dynamo machine, which may be erected at any reasonable distance from the scene of operations; all that is required to convey the power being a pair of insulated cables, which can be easily brought into the innermost parts of the forest. The felling machine itself is lighter and smaller than a corresponding steam saw, and can therefore be taken over difficult ground and through narrow places where the former could not pass. It was constructed at Buda Pesth, especially for the use in the Galician forests. The separation of the tree from the stump is in this case not effected by a saw, as is usual, but by a special drill. According to the nature of the wood, this drill may be used either to perforate the base of the tree with a series of holes, placed so close together that when the operation is completed all the fibers have been cut through, or it may be used to take a sweeping cut, in which case the tool is shaped somewhat in the fashion of a twist drill, but with prominent cutting edges along its side. The latter method is adopted for medium hard and for soft woods, The electromotor with its platform is placed on a light two-wheeled carriage, which is taken close up to the tree, and shackled to it by clamps and chains, the latter being attached to the axles of the carriage in such a way as to be readily detachable, so that the carriage may be quickly withdrawn if there should be danger of the tree falling before the operation is completed. The platform of the motor is mounted upon a vertical spindle in such a way that it can swivel in a horizontal plane. The drill is carried in a spindle, which receives motion from the motor by means of belt gear, the spindle being provided with a long key bed, and the pulley with a fast feather, so that the spindle may be shifted forwards or backwards by means of a rack. The mode of operation is as follows: After the machine has been brought up to the tree and shackled to it, the current is switched on, and a sweeping cut of suitable depth is taken across the surface of the tree by slowly rotating the motor on its vertical spindle. The drill is then advanced by a few inches, and a second cut is taken in the same manner, until about half the thickness of the tree has been separated from the stump. When this point is reached clamps are driven in to keep the cut from closing up by the weight of the tree, and the operation is continued until a point is reached when it would not be safe to cut away more of the wood. The shackling chains are then loosened and the carriage is withdrawn.

to safe distance, after which the final separation of the tree from the stump is performed by a hand saw or by the axe."

The third apparatus to which we refer is a method for overturning trees, thus uprooting them instead of cutting the tree by the axe, and afterwards removing the stump. The invention referred to is a truck, or rather an axle and pair of wheels whose function is to transport the parts from place to place and furnish a convenient point from which to operate the machine. A heavy strut is placed against the tree at a suitable height and a chain running from the point where this strut touches the tree to the base of the tree on the opposite side. From this point, at the base of the tree, chains or rods extend back to the free end of the strut, thus forming a triangle of which the tree is one side, the strut a second and the rods or chains a third; suitable saddles or swivels permit of motion at the angles. A powerful jack is connected with the free end of the strut, which is thus raised and the jack and compound levers are intended to exert sufficient force through the strut to overturn the tree and uproot it.

It has not been our privilege to see either of the inventions described in operation, and we do not look upon them with special enthusiasm, the object of their presentation being to post our readers as to the improvements suggested, rather than to endorse or condemn any particular invention. THE EDITOR.

◆

AN analysis of the Texada Island, Washington Territory magnetite made by Mr. Edward J. Chapman, shows an average composition of

Protoxide of iron,	28.33
Sesquioxide of iron,	67.31
Oxide of Manganese, trace	trace.
Titanic acid,	0.11
Phosphoric acid,	0.07
Sulphuric acid,	0.09
Silica and siliceous matter,	3.97
Total,	99.88
Metallic iron,	69.00

This ore was smelted in the 10x50 foot blast furnace of the Puget Sound Iron Company, at Irondale. The hearth is five feet in diameter, and air is supplied through five four inch tuyeres. Charcoal is made in eighteen bee-hive coke evens, each holding seventy-five cords of wood.

Queries.

[The answers to queries which we present in this issue, relate to chilled castings, and taken in connection with the article on "Cast-iron Car Wheels," will, we feel confident, prove valuable additions to the literature of the subject. In query No. 4 Mr. Samuel D. Mills, superintendent of the Martel furnace, St. Ignace, Michigan, discusses the question of allotropism influencing the formation of chills. While in query No. 5, Mr. A. W. Whitney, chemist of the Whitney Car-wheel Works, of Philadelphia, treats of the characteristics of pig-iron for the manufacture of chilled cast-iron Car-wheels. THE EDITOR.]

QUERY NO. 4.—*To what extent is the formation of chills in cast-irons of the same chemical composition influenced by physical conditions?*

An inquiry into the possibilitty of allotropic action influencing the crystallization of "chilling irons," would necessitate long-continued and very close observation of the governing conditions under which the chills were cast, but a partial answer may prove interesting and useful as indicating the lines along which observations should be made.

We may first consider what "allotropism" is, and what instances we have of this action in other bodies.

"Allotropism" may be defined as a change which can be effected in the nature of a simple element by physical influences.

We have also "dimorphism" or "polymorphism" in compound bodies.

As illustrations of allotropism we may take those that are most familiar, namely, carbon, phosphorus and sulphur. Carbon presents itself to us under the forms of lamp-black, charcoal, graphite or plumbago and diamond, the first and last of these are the purest forms, the graphite generally containing from one to five per cent. of iron. The lamp-black is amorphous or without definite form, the diamond crystallizes under the octohedral or tetrahedral systems, and the graphite under the hexagonal system. Crystals, however, are very rare. These differences are caused by mode of formation and not by chemical difference.

Phosphorus offers three varieties also, the common form is semi-transparent, nearly colorless, wavy looking, its specific gravity is 1.83, it fumes in the air, fuses at 112° F. and takes fire at 148° F. The odor of this variety is well known. The crystalline variety may be obtained from this by allowing the melted phosphorus to cool very slowly, it then crystallizes in dodecahedrons, but its character does not appear to be otherwise changed. Thirdly, we have the amorphous variety, obtained by keeping common phosphorus at a temperature of about 470° F. for about forty-eight hours in an atmosphere of carbonic acid. It is red, does not fume in the air, is not ignitible by friction and may be handled with impunity differing thus in every respect from the vitrous phosphorus. There is also a black phosphorus but it is not a stable form as it gradually returns to the condition of common phosphorus. Sulphur in its ordinary form is a substance with which every one is familiar, it melts at 239° F. If it is heated to about 370° F. it changes from the clear, thin yellow liquid which it forms at the former temperature, to a dark viscid condition resembling thick molasses. If this is poured into cold water it consolidates into a soft elastic semi-transparent substance totally unlike the common sulphur.

These are instances of allotropic action resulting from physical causes in the case of simple elementary bodies

We have numerous instances of dimorphism in compound bodies, as, for example, carbonate of lime which crystallizes from cold solutions in the form of rhombohedrons (belonging to the hexagonal system), and from hot solutions in forms belonging to the trimetric system, the two varieties differ in hardness as well as in form. Crystals of zinc-sulphate, if heated to 126° F. change from the *right rhombic* system to the *oblique rhombic.* The minerals *bromlite* and *baryto-calcite* are of the same chemical composition, yet they differ both in crystalline form and hardness. Titanic acid occurs in three distinct forms known respectively as *rutile*, *brookite* and *anatase.* Nickle sulphate crystallizes from solution below 59° F. in right rhombic prisms, between 59° and 68° F. in acute square-based octohedra, and above 86°, it forms oblique rhombic prisms. Numerous other instances might be mentioned in which the chemical composition has nothing to do with the variation in form, this being caused solely by physical influences.

Again, we may notice the fact that the presence of large and varying quantities of impurities of different kinds has no influence on the crystallization in many cases. *Bromlite* above mentioned may contain over 9 per cent. of manganese carbonate, yet its crystalline form will remain the same, and so with all crystalline minerals. Crystallization, therefore, within certain limits appears to be independent of chemical composition, and in the case of an alloy, such as cast-iron really is, it would appear that so long as the composition is such as to permit of that form of crystallization called "chill," the character of that "chill" is determined by altogether different causes. Every one who has had to do with chilling irons must have noticed the extraordinary difference that is caused in the chills by a variation in the rate of filling the mold, also by difference in the temperature of the molten metal.

In the casting house we frequently find that the chill-pigs farthest from the runner show the best chills, at other times the reverse holds good, sometimes the beds nearest to the furnace show the best chills, at other times those farthest away are the best. A few months ago I had a cast in which the chills were all unsatisfactory except one, and that one was about the best and prettiest chill I ever saw, it is not reasonable to suppose that one chill-pig (in the middle of the cast) could differ in chemical composition from all the rest of the cast. Had I been prepared for such an occurrence I might have detected the cause; it may have been from a little less moisture being in the sand just there, or a draught of cold air from one of the doors blowing just in the right spot at the right time, or any one of half a dozen such like "unconsidered trifles." This much is evident, if the variation in the chill is caused by chemical differences, then it is useless to attempt to control it; for sometimes the variations in the chills would show that the composition of the ore changed from hour to hour, and was beyond the possibility of adjustment. On the other hand, if the variation is of an allotropic character and produced by physical causes, care must be taken to avoid any difference in physical conditions in each separate cast. Changes in the temperature of the furnace will produce differences between successive casts, but the variations in the chills of any one cast will probably be found to arise from the following causes, viz: Difference in degree of moisture in the beds, differences in the rate of filling the molds, differences in the length of time the chill blocks have been in use (they became apparently burnt and lose in conducting or chilling power by long service), difference in the grade of metal of which the chill blocks are made, (the softer grades having less conducting power), differences in size and thickness of the chill-blocks. (these should be absolutely uniform). In a well-managed car-wheel foundry the conditions of casting are practically invariable, or perhaps we might better say, controllable, they can be varied at will in some respects by the founder, if the furnace man wishes to supply the car-wheel founder with metal which can be relied on to produce certain results it is necessary that the conditions under which he makes his tests should likewise be invariable or controllable. This is, in the casting house, not a matter of such easy attainment, as it would appear at first sight. Much can, however, be done by constant attention and watchfulness, and in this way only can it be decided, how far the nature of the chill is influenced by chemical composition, and how far by physical conditions, at present it appears that a very wide variation in the the nature of the chill can be and is produced by allotropic action.

A collection of data showing the modes of testing, grading, etc., in use at various furnaces with results of experience in these matters would probably prove very interesting.

SAMUEL D. MILLS.

QUERY NO. 5.—"*What are the requirements as to physical characteristics and chemical composition of pig-iron for the manufacture of chilled iron car wheels?*"

It is, of course, impossible to lay down any strict rule in regard to the above requirements, as the practice of wheelmakers varies much, some finding a few irons to give good results, while others use many and various irons. In either case an iron may at one time with one mixture work well, and at another time with another mixture be worthless. It cannot be said of such an iron that it is not a good ingredient of car wheel mixtures, but merely that it will not work well with the particular mixture with which it failed. It is largely the object of the chemist to ascertain with what irons it can be used.

In general, in regard to the physical character of car wheel pig-iron, the great requirement is uniformity. The character being once ascertained should not vary in different shipments. The chill test on the side of pig is useful; but would it not be well if furnacemen could go further and apply Keep's tests, or an equivalent, to their product? Small sample pigs might be run off from the larger pigs; 50 pounds or less melted in a covered crucible would probably give chill tests and other test pieces which would be useful as an indication of the quality of remelt of the larger pigs. Would not iron graded in this way give more uniform results? This would be an interesting question for practical investigation.

In regard to chemical composition the same may be said. If uniform as received at different times, the wheelmaker will know from his experience, or perhaps in the future from his chemist, it what cases any particular iron may be used. As a rule, I should say that good chilling irons, exclusive of white or mottled, contain between 0.56 and 0.95 per cent. of silicon, though there are some good ones with silicon above and below these limits. White irons often contain less than .15 per cent. of silicon. Manganese may be between 0.08 and 0.90 per cent., phosphorus, 0.05 to 0.75 per cent., sulphur, 0.0 to 0.15 per cent., and total carbon always as high as the above mentioned ingredients will allow.

There are, therefore, probably several proper compositions for wheel mixture, each of which depends for its physical success upon the manner of working the iron as to fuel, blast, temperature, etc.. and on the relative proportion of one element to another, as well as on the actual amount of each present. Thus some makers may allow as much as 0.95 per cent. silicon in a car wheel by properly balancing it with other elements, or by special methods. Others using different irons will keep the silicon even below 0.6 per cent. As yet this is generally done empirically, not by deduction from chemical analysis, which however, within certain limits as already intimated, can probably predict the results for any given method of working. I am of the opinion that, other things being equal, a small change in chemical composition affects the result; and that a different mode of working affects the result not only directly, but indirectly, by influencing the chemical composition.

The following is an analysis of a remarkably strong wheel with good chill, 33″ double plate wheel, weight 569 lbs., cracked slightly at 20th blow of a Pennsylvania railroad test drop, not broken at 425th blow of same drop. It then broke at the 3d blow of a 600 lb. drop falling 12 feet. The chill of this wheel was hard, one-quarter inch deep at root of flange and one-half inch deep in tread.

	Per Cent.	
Silicon,	**0.734**	
Manganese,	**0.438**	
Phosphorus,	**0.428**	
Sulphur,	**0.080**	
Total carbon,	**4.330 ?**	**(approximate).**
Graphitic carbon,	**3.083 ?**	**"**
Combined carbon,	**1.247 ?**	**"**
Copper,	**0.029**	

A. W. WHITNEY,
Philadelphia.

ONE of the standard arguments brought forward against the iron trade, is excessive profits from manufacturing processes, and yet, one or two failures are sufficient to practically weaken general confidence in the stability of the business. The necessity for large investment of capital in the production and manufacture of iron is generally recognized, the returns from this capital are as commonly believed to be satisfactory, if not excessive, which it is fair to presume should inspire confidence; and yet, general demoralization seems to follow in the wake of business failures in the iron-trade, which if occurring in other lines of investment would attract little attention outside of those closely associated with the organizations affected. The production or manufacture of iron is very sensitive to mismanagement, and insufficient capital soon results in precipitating disaster, but the fact that one iron works succumbed to extravagant management, or that another was rendered unremunerative by reason of excessive interest charges, should not work general mistrust in a business which is among the most stable; nor should confidence in the iron-trade be weakened by failures directly traceable to errors in judgment or mistakes in execution which are not more numerous proportionately than in other lines of business. If the profits are as great as generally believed, a few failures should have little effect on the industry.

Cast-Iron Car Wheels.

The following extracts from a discussion upon the manufacture of chilled cast-iron car wheels, are presented to our readers in the belief that there will be found much of interest in the views expressed by the prominent founders who participated in the discussions at two meeting of the New York Railroad Club. We have condensed the data from very full and lengthy discussions. to bring out the points of special value to the readers of the JOURNAL, making the remarks appear at times as disconnected, to the prejudice of the speakers, but the discussion was much too voluminous for reprinting, and we have attempted to get the items of especial interest, into the most convenient arrangement without altering the phraseology of the participants in the discussion, in preference to placing the data in better shape at the risk of misinterpreting the opinions of others.

Mr. J. N. Barr read a paper in which he stated that a perfect cast-iron car wheel should answer to the following description:

1. The tread should be perfectly cylindrical.
2. The tread and inside of flange should be perfectly smooth, and free from any defect that would impair the integrity and homogenity of the metal forming the parts subject to abrasion, and should conform in outline to the chill.
3. The body of the wheel should be sound and smooth, and free from any of the defects usually seen in castings.
4. The wheel when broken should show a shell of white iron, extending inward from the parts subject to abrasion, not less than three-eighths of an inch, nor more than three-fourths of an inch thick, and this shell should not vary in thickness in the same wheel.
5. There should not be a distinct line of demarcation between the white and grey iron, neither should the gradation from white to grey be very undecided.
6. The grey iron forming the body of the wheel, should be of medium grain, dark color, a ragged fracture, free from imperfections or white iron.

In practice wheels never realize the above description, their im perfection being more or less impaired by the following defects:

1. Chill cracks; 2. Rough treads; 3. Slag in tread; 4. Sweat and depression at throat; 5. Irregular depth of white iron; 6. Too great or too small depth of white iron; 7. Lack of roundness.

There are other defects, which are also common to general castings, but they will not be discussed here.

The mold in which car wheels are cast consists in general of an iron ring shaped on the inside to form the tread and inside of the flange. The remaining part of the mold is composed of sand as for ordinary castings. The iron ring, or chill as it called, causes the molten metal to cool rapidly, forming white iron; and it is on the depth. hardness and perfection of this shell of white iron that the durability of the wheel depends.

The molten metal enters at the hub spreads over the sand forming the bottom part of the mold, thence through the depressions in the sand which form the brackets into the flange. When the molten metal rises to a level with the point of the flange, it first comes in contact with the chill. It then gradually rises, covering the inside of the flange, the throat and finally the tread, until the mold is filled. The length of time consumed in pouring varies from twenty to thirty seconds, sometimes falling below the minimum mentioned, and sometimes exceeding the maximum. In general an interval from ten to fifteen seconds occurs between the time the molten metal first touches the chill, and the time the chill is entirely covered. Numerous experiments have been made which show that when molten metal is poured against a chill, a contact of ten seconds is sufficient to form a solid shell nearly one-fourth of an inch in thickness. We, have then, in the ordinary process of pouring a wheel, at the instant the mold is filled, the following conditions: a shell of metal nearly one-fourth of an inch in thickness has been formed against the flange portion of the chill, and this gradually decreases, until at the top of the chill, the shell is just beginning to form, his shell as soon as it forms, starts to shrink, the chill is rapidly abstracting heat from the molten metal and starts to expand. The body of the wheel is composed of molten metal which exerts an outward pressure against the tender red-hot shell of metal, which has solidified against the chill and resists its contraction. The shell of metal formed against the chill gradually thickens and contracts, the chill itself expands and the body of the wheel solidifies. In the operation above described it is more than likely that before the shell forced against the chill has reached an average thickness of one-quarter of an inch, entire separation has taken place between the chill and the shell and the hardening influence of the chill is no longer felt. Experiments demonstrate that if a block of cast-iron be formed against a chill, and the chill removed in less than forty seconds, the depth of the white iron will be less than if the chill were allowed to remain until the block had cooled. Many measurements made of the depth of white iron in wheels, and of plain chilled blocks of the same metal, show that the maximum and minimum depth of white iron, measured at the middle of the tread is seventy per cent., and fifty per cent. respectively of that of the block, and measured at the throat is fifty per cent. and thirty-three per cent. of the same. The decreased depth of white iron on the wheel as compared with the plain block is due to the separation between the chill and the wheel before the chilling operation is completed, the variation around the tread to earlier separation at some points than at others. This trouble is very much increased by slow pouring.

Too great or too small depth of white iron is a matter of the chilling quality of the metal used, although it can be modified, by the manner of pouring. In the first case, brittle and unsafe wheels are produced; in the other, wheels which are deficient in durability.

The following circumstances continually militate against the production of a perfect wheel: First, the tendency to chill crack, forcing the molder to pour molten metal at too low a temperature and too slow. Second, slow and cold pouring produces rough treads, slag in tread. sweat, lack of uniformity in the depth of white iron. Third, the expansion of the chill and contraction of the wheel produces lack of roundness, variation in chill and a reduction in depth of white iron as compared with the normal chilling qualities of the iron used. In order to obviate and reduce as much as possible the difficulties peculiar to wheel-making as described above, the writer has devised what is now generally known as the contracting chill. The ring which constitutes the ordinary chill is divided into ninety-six sections by radial divisions. These sections or blocks are held in position by an outside ring which is capable of being expanded or contracted, thus causing the blocks composing the chill to be moved radially outward or inward. By this means the expansion which occurs in the ordinary chill is entirely prevented, and the inward radial motion of the chill blocks is such as to extend the time of contact between the chill and the contracting wheel within, until nearly the full effect of the cooling influence of the chill is obtained. The expansion and contraction of the outside hollow retaining ring is effected by introducing steam or cold water.

There is one objection to the wheels made by the contracting chill, the small ridges formed by the spaces between the chill blocks produce a very perceptible and unpleasant buzzing sound for some time after they are placed in the service. After many endeavors to remove this objection by more perfect molding, the writer has come to the conclusion that the only practicable way of avoiding this difficulty is to trim the ridges off with a grinding machine.

Mr. W. T. HILDRUP said in discussing the paper:

In the beginning of railroads, prevailing forms in other vehicles were the models for imitation. Thus wheels were spoke wheels, some of wrought and some of cast iron, the cost of the former was so great that cast-iron was the effort from the beginning. Spoke wheels were made with the hub split into three or more pieces, and when cold the interstices were filled with zinc. poured in a melted condition, then banded on either side to make a firm hub, bored out, the axle turned, both slotted and pressed on by geared machinery working a screw for pressure, then, when in place, keyed to secure it from moving. Hydraulic presses were unknown for such uses, nor were the hubs firm enough to endure the pressure. Next came various forms of plate wheels. Two firms introduced the double plate joining the rim and hub, the latter made solid, with the hub in some instances cut through between the plates, to allow the contraction and expansion by lengthening or shortening the hub under the changes of temperature. Another form was by corrugated plates, corrugations running across the tread and hub in crescent form from the hub to tread; next a double plate center, with the corrugations spiral and straight, occupying about one-half of the face of the wheel; and many other forms too numerous to mention. One of them is important, as it was the beginning of the present form now generally in use. All these efforts were made to accommodate certain positive features of elements entering into the formation of the wheel.

Many people made wheels, which were modifications and combinations of the various forms named, patenting the same until the expiration of the Washburn patent, when this form entered into almost general use.

In all the efforts to use cast iron, one necessity was always dominant—change of size by change of temperature. It is a positive law of nature that heat expands and cold contracts. all the efforts in the origin and perfection of car wheels have been in obedience to this law of change of size by change of temperature, both in the manufacture and in the service required. Early in this line various devices were used for cooling the heavier parts in the same time the lighter ones would cool, so that all would come to their fixed sizes at the same time, to prevent what is technically termed strain, until now the universal practice is annealing pits; that is, in close, dry well-shaped pits, in which the wheels are placed to slowly cool all parts alike until all come to a fixed condition. This necessity may fairly be said to have been mastered by prevailing methods. There are now no difficulties in securing the thick and thin parts of a car wheel in easy position in the manufacturing processes by the common methods faithfully adhered to. In service, the same law of expansion and contraction by change of temperature is still a factor of largest moment, and one not yet fully mastered. On long, heavy grades, where the continuous application of the brake by friction, heats up and expands the tread, while the interior parts do not receive the same heat and are thus relatively of less size, there comes a strain on the metal that is greater than its tenacity, and thus a crack when once started, if neglected, produces a broken wheel.

In the metal in a wheel there is a crushing force direct from hub to rim, also centrifugal force; but the greatest tax is by expansion of the tread, by the heating from the brake when tortion occurs.

Should the interior plates be made one-quarter of an inch thick with ordinary chilling iron, the two cold surfaces of sand would chill them into white iron. At one-half inch there would be a modified degree of the same condition, whereas at three-quarters of an inch thick the tendency would be entirely over-balanced, and we secure a condition of close, firm, elastic iron. The central part of the wheel is subjected to compression on the downward portion of the wheel; expulsion by centrifugal forces, rapidly changing with the quickly varying positions under conditions of constant strain from concussion and tension, giving us some idea of the forces working on the molecules composing the mass. Then add tension by expansion of the tread, and we get a combination of forces, intense and multiplied in their changes, that would seem to be impossible for the practical limits of the strength of cast iron. Weight of load and speed of trains develop the higher demands made on the wheel, and intensify the interior strain put on it. The tensile strength of cast iron is a given quantity, varying with different qualities. Tensile and elastic strengths are the prime requisites resisting these forces ot constantly recurring strain, frequently over-taxed.

Car wheel makers keep constantly in mind all these conditions of elements, forces and requirements, and have made great progress in the perfecting of car wheels. What have the railroad people done? Starting on the supposition that the wheel makers are earnestly working on the problem of securing the best results possible under the limits imposed on them, loading and speed have been quadrupled; warranted service is not reduced for these requirements; prices are lowered by competition among manufacturers, and the whole question is weighted down by pressing exactions from all sources. To meet this demand of increased load and speed, cars, trucks, axles and springs all have been proportionately increased. It is manifestly to the interest of all parties that some provision should be made in wheels in the same direction. Axles break, and you increase the size and weight. Wheels break, and you discredit the maker. Your own judgment will point out to you that increased material should be provided in wheels, as well as in other parts of the vehicle, and in my judgment tne weight of a wheel for a sixty thousand pound car should not be less than an average of six hundred pounds. Such can be allowed with greater economy than in any other part of the structure. The increased cost is simply that of iron and melting for the increased weight, nothing more for molding, cleaning, trimming or fitting, the increased dead weight is in position, requiring least force to move it. The increased cost is, a large proportion of it, returned in the end in old metal. Some who are making this demand in their new equipments, are in my judgment pioneers in the direction which we will follow at no distant period.

The history of the highly perfected development of cast iron car wheels is from many efforts, on theories propounded from many brains. The mass of such theories have marked the road all along the line as failures, yet good and substantial progress has been made, and cast car wheel makers may well be proud of their advances. They have fought their way along the line with wrought iron and all kinds of steel wheels, and they still roll along. Their economy, durability and efficiency stand their backers for their staying qualities. The wrought iron wheel, the paper wheel, the steel wheel have come, and some have gone; others may follow, while the cast iron wheel takes a new grip on the railroad confidence for its sterling qualities on an economic basis.

In the forty years I have been a wheel maker I have seen many new claims for superiority. I have seen a great plant, sanguine in the minds of the management, starting out on great discoveries, land in discredit. I have seen, on the opposite, good common sense, sticking to known methods, plod its way along in years of successful operations.

I think Mr. Lobdell is the oldest car wheel-maker in the United States to-day; he has been identified with wheel manufacture from its earliest history, and he could give information that would be exceedingly interesting.

Mr. GEO. G. LOBDELL. I think that wheels for 60,000-lb. cars should weigh at least 600 lbs. I am willing to admit that a good wheel weighing 575 lbs. can be made, one that will stand the test of the railroad companies, but I know that a better and safer wheel can be made if it weighs 600 lbs. Wheels weighing 600 lbs. will admit of a harder and more durable character of chill, and yet possess sufficient strength and elasticity to resist the shocks to which they are subjected, and the expansion of the tread by the application of the brakes.

Of whatever weight the wheel may be, the different parts should be in such proportion, and of such a form as is best calculated to give the greatest strength and durability. The best form, in my opinion, to produce the most perfect and lasting chill, and to counteract the tendency to crack in the brackets from the expansion of the tread from heating by the application of the brake, is the old double plate wheel. Many wheels of this pattern have given great mileage; some master mechanics and superintendents prefer them to any other form for engine truck wheels.

As a wheelmaker, I care not what the physical test is so that it it is universal. While these tests do not make it certain that each wheel in the lot is equal to the one tested, I have no doubt it will prevent the use of many inferior and unsafe wheels. There are many wheels now in use that would not have been put under cars if this test had been required.

We show a twenty-eight inch wheel that had made eighty thousand miles under an engine on a crooked road. We have an old wheel in our shop now that was in use and was supposed to have made five hundred thousand miles on the Erie road under a freight car. Many of them have made a very great mileage.

Mr. HILDRUP. I fully believe with Mr. Lobdell that the double plate wheel is the best; it is less liable to crack: it yields more uniformly. But it costs fifty cents a wheel more to make. We are making box cars carrying sixty thousand pounds load, and the car will weigh thirty-five thousand pounds itself; and we are running them at the rate of forty miles an hour. Twenty-five years ago the maximum load was eight to ten tons, and there was a fine put on if you got much above that. We are rapidly developing a more perfect machinery, and you are not going to neglect car wheels a great while longer. The five hundred and fifty-pound wheel of to-day is a wonderful development.

Referring to the chills on car wheels Mr. Lobdell said: It is well known that when certain kinds of molten iron are poured against a metallic mold, that portion next to the mold becomes hard, white, crystalline and brittle, while the interior portion remains gray, and more or less tough and fibrous. This conversion of the part that strikes the metallic mold into the hard, white, crystalline metal is called "chilling." Different brands of iron made from different kinds of ore, or from the same ore but under different conditions of the furnace in which the ore is smelted, possess greatly different chilling properties. This mainly depends on the proportion of free carbon (graphite), silicon, sulphur, etc., and the proportion of these substances not only effects the depth to which the chill or hardness extends, but also the degree of hardness or wearing properties, and the density of the iron or its specific gravity, and its tendency to shrink. Metallurgists tell us that when most cast irons are melted and cooled suddenly, the carbon in the iron is all retained in the combined form; but that if the cooling is effected slowly it separates partly as free carbon or graphite; and the chief chemical difference between the chilled iron and the soft iron of the same wheel or other article cast in a metallic mold is in the carbon, that in the chilled portion containing it in the combined state, whereas that of the soft or gray portion, while also containing some in the combined form, has more or less of it separated in the shape of graphite. I have no doubt that the chilling or hardening takes place in a very few seconds from the time the molten iron strikes the chill. Mr. Barr stated that he had ascertained from experiments made that ten seconds were sufficient to produce a chill one-fourth of an inch in depth. I have no doubt that in many cases a greater depth is produced in that time. I am not able to say what degree of heat is necessary in order that the metal mold shall not affect the molten iron, causing it to crystallize and harden; I do know that it must be above the degree of heat of steam, and that molds heated above that temperature make a hard and durable chill, and are less liable to chill cracks and some other defects. I have with me a section cut from a chilled roll; you will notice that the character of the chill is perfect, and it can not be filed with a fine file. These rolls remain in the iron molds from twelve to twenty-four hours, and sometimes the mold or chill becomes so hot as to adhere or to be welded to the roll, and this without destroying the chill of the roll. You were told that the expansion of the chill and the shrinkage of the rim of the wheel away from the chill, while the iron back of the chilled portion was in a liquid or plastic state, lessens the hardness or durability of the chill, and that sectional chills prevent this effect. That this is not the case, I infer from the fact that in casting large chilled rolls, from sixteen to twenty-four inches in diameter, the center of the roll remains liquid at times for more than an hour. I know that this is the case, because as the roll contracts in cooling more or less iron will be forced out at the sink head, often as much as fifty pounds, and continuing for nearly an hour. If the liquid iron next to the chilled portion has the effect claimed, then it would be impossible to make a large roll with a perfect chill.

The character, depth and degree of hardness depends on the proportion of carbon, silicon, phosphorus, etc. This change or chilling, produced by sudden cooling, no doubt takes place in a very short time, and is not afterwards affected by any degree of heat much below the point of fusion, and judging from my experience in casting chilled rolls I should say that it is not affected by being in contact with the liquid iron in the interior of the casting while this is in a quiescent state.

Heating chills by steam or otherwise is not new. All chilled rolls are cast in heated chills. In 1862 a patent was granted for chills or molds in which railroad wheels are cast, heated by means of steam, hot air, etc., introduced into an annular space formed in the chill.

Mr. CHAPIN. We had a case the other day of a car of material coming into our yard overloaded. It was in a twelve-and-a-half ton car, and when we weighed it and the empty car we found that there had been twenty-eight tons in a twelve-and-a-half ton car.

Mr. HILDRUP. A broken wheel is a very expensive thing. We know the best of wheels will crack under certain conditions, and if the inspector don't find them there will ultimately be a broken wheel. To me it is oftentimes a question how it is possible for cast-iron to meet the strain that is put on it. By increasing the thickness of the tread, by that means allowing a greater chill and a harder chill, we impair the safety of the wheel. All railroad wheel makers know that a hard plate, a plate approaching mottled or white iron, will be brittle. We know that metal in certain conditions, in a sand mold, will chill a certain thickness; seven-eighths is a large provision for safety against any hardness or brittleness of plates, and again it is providing metal that any careful mechanic will see is well applied; it is well applied for safety, and I fully believe, that inside of five years, and probably inside of two years, 650 pounds will be considered the desirable standard for wheels for a thirty-ton car.

Mr. P. H. GRIFFIN. We have manufactured cast-iron wheels for many years, have given careful attention to the results obtained from them and to their possibilities. Our experience and investigations have convinced us that the cast wheel, properly made, has everything in its favor for any class of service—freight, passenger car or locomotive.

For safety, we have a record of 300,000 wheels made and put in every kind of service during the past five years, out of which not one case of breakage has occurred. As to economy of use and ultimate cost, that depends principally on the service obtained. It is a fact well known that cast wheels do not go into service under proper mechanical conditions. The work of boring the wheels for fitting on axles is often carelessly done; the boring tools are frequently in bad shape. and the most careful workman could not do proper work with them. The consequence is that wheels go into service more or less out of round and out of balance.

When we consider that under 60,000 lb. cars each wheel must sustain under the most favorable forms of construction, including the weight of the car, a load of five tons; that it must revolve 275 times per minute in running at a speed of thirty miles per hour; that it must, under these conditions, withstand all kinds of brake service—it is not difficult to conclude that proper mechanical conditions must accompany this service if a good result is to be expected.

Mr. W. T. HILDRUP, Jr. From experiments conducted in our foundry, we have found that some mixtures of iron are more apt to produce chill cracks than others. We attribute this largely to the presence of sulphur, either in the iron or fuel, and try to keep our fuel as free as possible from this element. The chill cracks, all of which are scrapped, is about four per cent. of our make, representing a loss in labor, fuel, etc., of say about eight cents per good wheel. To make a good wheel the greatest care and watchfulness is necessary, not only in the mixture of the irons, but in the manipulation of the cupola; the best of wheels are those poured from the hottest iron. The difficulty with slag we have overcome, first by the introduction of a slag tap in our cupola, and by carefully skimming the iron in the wheel ladle before it is poured. We have found that as high as four-tenths of one per cent. of phosphorus in the mixture materially improves the smoothness and hardness of the wheel, and that with this percentage of phosphorus a percentage of manganese as high as eight-tenths of one per cent. gives strength to the iron and does not produce a soft chill. We have never had the least difficulty with any of the tests so far specified for rotundity of the wheel, our chills being turned accurately to a template, and renewed when cut or cracked at an expense of not over two dollars per chill, deducting the value of the iron in the discarded chill. We have found that the drop test is a very reliable one, and that any attempt to so proportion the wheels to meet this test by taking metal away from one part of the wheel and thickening the wheel in other places is not successful, from the fact that a wheel properly proportioned and properly annealed will stand more blows under this drop test than a wheel with fifty pounds more metal but of bad design.

Mr. WHITNEY. The contracting chill which we use at our works is cast in one solid piece, the divisions between the segments being formed at the time of casting. These divisions are so fine that you can barely slip a sheet of paper in between two segments. If you double an ordinary sheet of writing paper it will not go in those spaces. I think our thirty-three inch chill has a little over 100 such slots. Those slots are about one one hundreth of an inch in thickness. They are formed in the process of casting, but there being 100 of them the chill can contract nearly an inch in circumference, although each slot is only a hundreth of an inch in width. The consequence is that there is no perceptible mark made on the tread of the wheel. The wheel is perfectly smooth, as smooth as if made in an ordinary chill, and it is free from blemish. The chill we use is so constructed that it expands inwardly, and then as the heat is conducted to the outer ring it expands. This expansion is perfectly uniform all over the chill. The chills in use over two years, are to-day just as accurately round as the day when they came off the mill in which they were turned. We have had steel tires coming to our yard to be fitted up. We have tested them and found the chilled wheel as near to being accurately round as the steel tired wheel which had just come off the lathe, and it will be generally so. They will also be of nearly the same size.

The depth of the chill upon a wheel according to my experience is due very much to the thickness of the chilling surface. If the chilling surface is one-eighth of an inch thick, you will not get very much chill on your wheel. If it is, however, an inch thick you will get a deeper chill. If it is an inch and a half thick, you will get a still deeper one, if it is three or four inches thick, other things being equal, you will get a still deeper chilling effect produced upon your wheel. My judgment has been for many years that a very much heavier tread of wheel than formerly is required for the service which is now exacted by railroad companies. You are using a steel-tired wheel, the thickness of which is two and a half inches, put upon a center of an inch and a half thick at least, to bear the blows and hammering of a heavy load. Now you put under your sixty-thousand-pound car a cast-iron chilled wheel, with a tread an inch an three-eighths, or an inch and a half thick, to stand the same blow. Your anvil is too weak for the forging you are making upon it. You want a wheel of heavier tread, and I am very glad to see that one of the railroad companies in New England has realized this sufficiently to stipulate that the wheels that are made for them shall have a tread two inches thick. The difficulty in making such a chilled wheel heretofore has been the expansion of the chill from the wheel, and the contraction of the wheel from the chill. With the contracting chill, however, if you have body enough of metal in the chilling surface, you can make any thickness of tread.

Mr. LOBDELL. Mr. Barr predicates the value of the sectional chill, and so does Mr. Whitney, on the theory that the chill expands inwardly and meets the wheel as it contracts. Now to do that there must be an increase in the temperature of the chill. Some experiments were tried in our foundry which resulted as follows: The temperature of the chill before it was poured was forty-eight degrees. In thirty seconds after that, and after the wheel was poured entirely, it was but 52 degrees, the temperature having been increased about four degrees. That was long after the wheel was all formed and the chill all formed—thirty seconds on the outside. You cannot expand the inside until you expand the outside.

I have often had a wheel when half full to run out and leave a chilled crust around of a quarter of an inch or more in thickness. I have had a wheel to run out just as it was full, and it would leave the entire flange all of a certain thickness. I have had occasionally a chill roll, weighing from twelve to fourteen thousand pounds, to break out at the bottom and leave a chilled ring from one inch to an inch and a half in thickness. I doubt if Mr. Whitney's chill meets the contraction of the wheel to any degree; and as for the roundness of the wheel—we have had probably from forty to fifty thousand wheels inspected during the past year and a half, and have never discovered a wheel that was over one sixty-fourth of an inch out of round. We have no trouble with the sweating of the flange of the wheel.

Mr. HILDRUP. I frequently have had a mold break, or a chill break, when a wheel was half full, that relieved the wheel at once from all pressure and the chill would be as nice as on any perfect wheel. Mr. Whitney remarked that treads are too thin—too light. They are, but car wheel makers have found that one very important thing in a car wheel was to balance it in annealing. A two and a half inch chilled tread attached to a three-quarter inch plate by all the processes of annealing that I knew of would be very difficult to balance in the annealing. It takes a great while longer for two inches and a half of iron to cool, than it does for three-quarters of an inch, and especially when it is in such a position that the air gets at both sides, with free access on the three-quarter inch plate, and it is protected on the inside of the two and a half inch tread. What would be the benefit of a two and a half inch tread? Do you want any more material there than what is sufficient? Wheels break through the tread rarely. They break under certain conditions when exposed to violence.

Mr. WHITNEY. The point is not, whether the chill contracts, or does not contract. If it will contract it is all the better. But the main point is that the chill shall be kept in contact with the wheel until the full chilling effect is produced. After that you take the chill away. If you cast a sample against a chilling block of iron, and in ten seconds or less move it back from the iron, the heat of the molten metal will draw the chill out; there is no question about that. If you take a block of iron and pour a sample against it of any size, and let it lie there a few seconds, a chill will be produced upon the sample of iron. If you run a thin knife blade down between the sample and the chill, however, within ten seconds after it is poured, you will find that the chilling effect on the sample will be very materially reduced. In some irons it will be almost entirely removed. In other irons it will be reduced one-half or one-third. the heat of that part of the sample which has not yet solidified, will draw out the chill which has been produced in the first place. Now, if you can keep the chill in contact with the wheel as long as required to produce the full chilling effect, you have accomplished all that is necessary. The trouble is, when you pour the metal into the mold the ordinary chill is heated, is soon begins to expand and it goes away from the wheel. The wheel solidifies and begins to contract, and goes away from the chill; and there is a space of a greater or less amount left between the chill and the wheel, and if the metal is very fluid it will draw out the chill where the space is the largest. This is the explanation of the inequality of the chill produced at different points. You will have a deep chill where it lies close to the wheel, and a light chill where the separation has taken place to a considerable extent.

Some time ago I made some experiments with Salisbury iron, the shrinkage of which was .15 of an inch in a foot. I cast two wheels of that lot of iron. One in an ordinary chill, the other in the contracting chill. The ordinary chill when cold measured on its circumference 96.75 inches. The wheel cast in it when it was cold measured 95.625 inches. The Salisbury iron shrank as we have seen fifteen one-hundredths of an inch in a foot, which carried out gives 1.3 of an inch in the circumference. If there had been no expansion in the chill the wheel ought to have been the full size of the chill, less the natural shrinkage of the iron, or 96.75 minus 1.3. The wheel should have been 95.45 inches in circumference, but it was actually 95.625. It was larger than it ought to have been from the natural shrinkage of the iron. The explanation of that is that the chill expanded before the wheel solidified. When the wheel solidified, it filled the chill, which at that time measured more than 96.75, and the natural shrinkage of the iron brought it down to 96.625. If you cool water down from any temperature you please to about forty degrees, it contracts, becoming smaller and smaller in volume. However, if you still continue to reduce the temperature it begins to expand. At thirty-two degrees, when it solidifies, it expands with force and may break the vessel in which it is contained. Now, iron does precisely the same thing as it cools down to the point of solidifying. The moment it becomes solid it expands, just as water does, filling the mold perfectly to whatever size and shape the mold has expanded to at that time. So that the wheel expands to fill the increased size of the chill; then begins to shrink from that size. Now, in the contracting chill we had this result: The circumference of the contracting chill was 96.625, measured when it was cold. The wheel cast in it measured 95.25 when cold. Now, if the wheel had simply had the shrinkage of the iron, 1.3 it should have been 96.625 minus 1.3, or 95.325; it should have been a larger wheel than I got; the wheel was smaller than the natural shrinkage of the iron would make it. It is evident that as the wheel was smaller than it ought to have been by the natural contraction of the iron that the chill remained in close contact with the wheel during the whole process of the chilling. The consequence was, the depth of the chill is perfectly uniform all around the wheel.

You will notice in a wheel cast in the ordinary chill a variation in the depth of chill. In order to produce a good wheel that would be well chilled all over—the chill would be too deep in some parts—but at the lowest point it should be at least three-eighths of an inch deep—I would have to put in considerable hard iron, the consequence would be I would not have as strong a wheel. With the contracting chill, by keeping the chill in contact with the wheel during the whole process, I do not have to harden the metal, but get the full value and strength of the iron, and the iron is soft and elastic.

Mr. LOBDELL. In making chilled rolls we make a chill test of the bottom of the roll, we also make a chill test by taking iron out of the ladle and pouring that into a block. they seldom agree. I have known them to vary as much as one-half an inch, one block would have a chill of an inch in depth, and the other a chill of an inch and a half in depth.

Mr. BARR. The chill we use has a hollow ring on the outside. We circulate steam through it and it expands, carrying with it the blocks which are attached on the outside and which increase the diameter of the chilling surface. Of course, if you expand that ring you move your blocks outward, just the same way as if the ring was replaced by a chuck and you pulled outward on the block. The molder starts pouring the wheel. The man at the crane stops the steam and turns on a current of cold water, which cools the ring down and causes the blocks to move inward; we keep a stream running through it for twenty or thirty seconds.

Mr. CHAMBERLAIN. Ten or fifteen years ago, all we could get as an average mileage was thirty-five thousand miles. It seems to me if we have an expansive and contracting chill by mechanical force, or by the force of water acting as a mechanical power, the wheel must be made a little more dense. Now, the hotter you can pour your metal, I think, the stronger will be your wheel and the longer it will last, and by this squeezing process it must be condensed. In the wheels manufactured by the old system, as I said, thirty-five thousand miles was all that we could get as an average. Individual wheels have run ninety thousand, and hundred thousand and one hundred and fifty thousand miles, but it was a very rare thing that we got any big mileage.

Mr. WHITNEY. Wheels made in the old chills did, no doubt, show some excellent mileage, but wheels made in new chills do better. Take a wheel made in the ordinary chill, and a wheel made in the contracting chill, take a part of the wheel which has exactly the same depth of chill when made in the ordinary chill as the one made in the contracting chill, made out of the same iron, on the same day, and put the two pieces of wheel along side of each other, and you may not detect any difference. We inspect our wheels with a very highly, finely tempered chisel, used with skill and care.

A man that is accustomed to using that chisel may be blindfolded, and you may place before him half a dozen wheels made in an ordinary chill and a half dozen made in a contracting chill, and he will pick out every wheel made in the contracting chill by the difference of the cut. The metal is so much more dense that the chisel will tell it instantly.

Taking the specific gravity of those two specimens of chilled iron, the one made in the contracting wheel will be from one to three pounds heavier per cubic foot than the specimen made in the ordinary chill.

Mr. CHAPIN For the past ten years I have been interested in a foundry that has made in that time a quarter of a million of wheels, with the old style chill. We have never been free from out of round wheels, or free from blow holes, slag, wrinkles or chill cracks. In the last year we have been using some contracting chills and are pouring our wheels in ten seconds. The molder does not stop to cool his iron at all, but pours it into the mold just as soon as he receives it. Last month four molders using the Barr chill did not, all told, lose as many wheels from chill cracks as the fifth molder using the old style chill.

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American Pig-Iron in 1888.

In round numbers six and a half million gross tons of pig iron was the product in 1888 of the 589 furnaces reported as existing in the United States. The exact figures collected and published by the American Iron and Steel Association, are 7,268,507 net tons, or 6,489,738 gross tons, an amount that exceeds by 72,590 gross tons or a little over one per cent. the output of 1887, which had previously represented the maximum annual product of the American blast furnaces. The total number of furnaces in blast July 1st, 1888, was 290, and on December 31st, 1888, 333. If we assume the average number in blast for the year at 320, it will show that the blast furnaces which were active in 1888 averaged an annual product exceeding 20,000 gross tons each.

The production of pig-iron in 1888 classified according to the fuel used was as follows, compared with the production in 1883, 1884, 1885, 1886 and 1887:

NET TONS.

FUED USED.	1883.	1884.	1885.	1886.	1887.	1888.
Anthracite coal	1,885,596	1,586,453	1.454,390	2,099,597	2,338,389	1,925,729
Charcoal	571,726	458,418	399,844	459,557	578,182	598,789
Bituminous coal and coke...	2,689,650	2,544,742	2,675,635	3,806,174	4,270,635	4,743,989
Total..................	5,146,972	4,589,613	4,529,869	6,365,328	7,187,206	7,268,507

Mr. James M. Swank, vice president of the American Iron and Steel Association, says that "the anthracite figures include all pig-iron made with mixed anthracite and coke as well as that made with anthracite alone. The production of iron with anthracite coal alone is now annually less than that made with charcoal (it was 277,515 net tons in 1888).

If a tin-plate industry should be established in this country as the result of tariff legislation our production of charcoal pig-iron would doubtless largely increase. In an abundant supply of charcoal we have a great advantage over Great Britian, which now makes scarcely any tin plate from charcoal pig-iron."

Pig-iron was produced in 1888 in twenty-four States (counting Washington as a State), charcoal was used as fuel in nineteen States, bituminous coal and coke in fifteen States and anthracite coal alone, or mixed with coke, in three States.

The following table will show the number of existing blast furnaces and the amounts of pig-iron produced with the various fuels in the several States in 1888:

PRODUCTION OF PIG-IRON ACCORDING TO FUEL USED IN 1888, NET TONS.

STATES.	Total number of furnaces.	Produced with charcoal.	Produced with bituminous coal.	Produced with anthracite coal.	Total produced in 1888.	Increase or decrease from total production in 1887.
Maine, ...	1	5,574	. . . . . .	. . . . . .	5,574	+1,177
Massachusetts, . . .	4	13,248	. . . . . .	. . . . . .	13,248	+2,134
Connecticut, ...	9	21,644	. . . . . .	. . . . . .	21,644	—97
New York, ...	40	19,959	52,074	185,147	257,180	—39,392
New Jersey.	18	. . . . .	. . . . . .	101,882	101,882	—70,672
Pennsylvania, . .	238	15,139	1,935,347	1,638,700	3,589,186	—95,432
Maryland, ...	15	15,702	1,904	. . . . . .	17,606	—19,821
Virginia, ...	33	7,435	189,961	. . . . . .	197,396	+21,681
North Carolina, . .	2	2,400	. . . . . .	. . . . . .	2,400	—1,240
Georgia, ...	4	300	39,097	. . . . . .	39,397	—1,550
Alabama, ...	38	94,126	355,366	. . . . . .	449,492	+156,730
Texas, ...	1	6,587	. . . . . .	. . . . . .	6,587	+2,204
West Virginia, . . .	9	. . . . .	95,259	. . . . . .	95.259	+12,948
Kentucky, ...	7	5,054	51,736	. . . . . .	56,790	+14,883
Tennessee, ...	20	51,850	216,081	. . . . . .	267,931	+17,587
Ohio, ...	77	21,864	1,081,954	. . . . . .	1,103,818	+128,279
Indiana, ...	2	. . . . .	15,260	. . . . . .	15,260	+2,049
Illinois, ...	16	. . . . .	579,307	. . . . . .	579.307	+13,854
Michigan, ...	27	213,251	. . . . . .	. . . . . .	213,251	—292
Wisconsin, ...	12	69,757	46,280	. . . . . .	116,037	—17,471
Missouri, ...	11	28,297	63,486	. . . . . .	91,783	—46,860
Colorado, ...	2	. . . . .	20,877	. . . . . .	20,877	—4,414
Oregon, ...	1	2,509	. . . . . .	. . . . . .	2,509	+2,509
California, ...	1	. . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .
Washington, ...	1	4,093	. . . . . .	. . . . . .	4,093	+2,507
Total for 1888, . .	589	598,789	4,743,989	1,925,729	7,268,507	+81,301
Total for 1887, . .	583	578,182	4,270,635	2,338,389	7,187,206	. . . . .

PRODUCTION BY DISTRICTS.

The New England States, Maine, Massachusetts and Connecticut, produced in 1888 40.466 net tons, or 6.8 per cent. of the total charcoal iron output, a gain of 3,214 net tons, or 8.6 per cent. No mineral fuel iron was made in these States.

The Middle States, New York, New Jersey, Pennsylvania and Maryland produced a total of 50,800 net tons of charcoal iron, or 8.5 per cent. of the total make, a loss as compared with 1887 of 3,055 net tons, or 5.7 per cent.; 1,989,325 net tons of bituminous coal and coke iron, equal to 41.9 per cent. of the total make, a gain of 190,398 tons, or 10.5 per cent.; and 1,925,729 net tons, the entire product of anthracite iron in the country, a decrease of 412,660 net tons, or 17.7 per cent. from 1887. The aggregate output of these four States of all kinds of pig-iron in 1888 was 3,965,854 net tons, or 54.6 per cent. of the total manufacture.

The Southern States, Virginia, West Virginia, North Carolina, Georgia, Alabama, Kentucky, Tennessee and Texas, made in 1888 167,752 net tons of charcoal iron, or 28 per cent. of the total make, a gain over 1887 of 2,625 net tons, or 1.6 per cent., and 947,500 net tons of coke iron equal to 20 per cent. of the total make, a gain of 220,618 tons, or 30.3 per cent. over 1887. The entire manufacture of pig-iron in the Southern States was 1,115,252 net tons, or 15.3 per cent. of the total output of the country.

The Central States. The aggregate product in 1888 of the States of Ohio, Indiana, Illinois, Michigan, Wisconsin and Missouri was 2,119,456 tons, or 29.1 per cent. of the total make; the charcoal pig iron being 333,169 net tons, or 55.6 of the country's total, a gain of 12,807 net tons, or 4 per cent. The bituminous coal or coke output was 1,786,287 net tons, or 37.7 per cent. of the whole product, a gain over 1887 of 66,752 net tons, or 3.9 per cent.

The pig-iron output for 1888 of the Western States, Colorado, Oregon and Washington was 27,479 net tons, representing 0.4 per cent. of the total output of the United States. Of this 20,877 net tons were made with coke in Colorado, a decrease of 4,414 net tons, or 17.8 per cent. from 1887 output, and 6,602 net tons were made with charcoal in Oregon and Washington, a gain for this district of 5,016 net tons.

Comparing the returns for 1887 and 1888 from the sections of the country as above divided, we have the following table, upon which comment is unnecessary:

	New England States.	Middle States.	Southern States.	Central States.	Western States.	Total.
Percentage of the total make in 1887	0.5	58.3	12.4	28.4	0.4	190
Percentage of the total make in 1888	0.6	54.6	15.3	29.1	0.4	100
Total make in net tons in 1887	37,252	4,191,171	892,009	2,039,897	26,877	7,187,206
Total make in net tons in 1888	40,466	3,965,854	1,115,252	2,119,456	27,479	7,268.507
Increase of product in 1888 over 1887	3,214	....	223,243	79,559	6.02	81,301
Decrease of product in 1888 over 1887	....	225,317	....	....	....	....

PRODUCTION AND CONSUMPTION.

In the JOURNAL, Vol. VII, page 316, we presented a table showing for the years 1875 to 1887 inclusive the stock of pig-iron carried over from previous years, with the production and importation of each year. These three columns were added together to show the total available supply of pig-iron, and from this was subtracted the stock on hand at the close of the year to denote the apparent consumption. For the thirteen years under consideration, in no year was it found that the home production equaled the apparent consumption, the latter exceeding the former in varying amounts from 111,308 tons in 1877 to 773,563 tons in 1879. Taking the figures for the year 1888, we find the following:

Stock of pig-iron unsold December 31, 1887,	338,142	net tons.
Total domestic product for the year 1888, . . .	7,268,507	" "
Total importation of foreign pig-iron for the year 1888, ...	220,519	" "
Making a total available supply of	7,827,168	" "
From which deduct the total stock on hand December 31, 1888, ...	336,116	" "
Leaving as the apparent consumption of pig-iron for 1888, ...	7,491,052	" "

Or over 200,000 tons more than we produced.

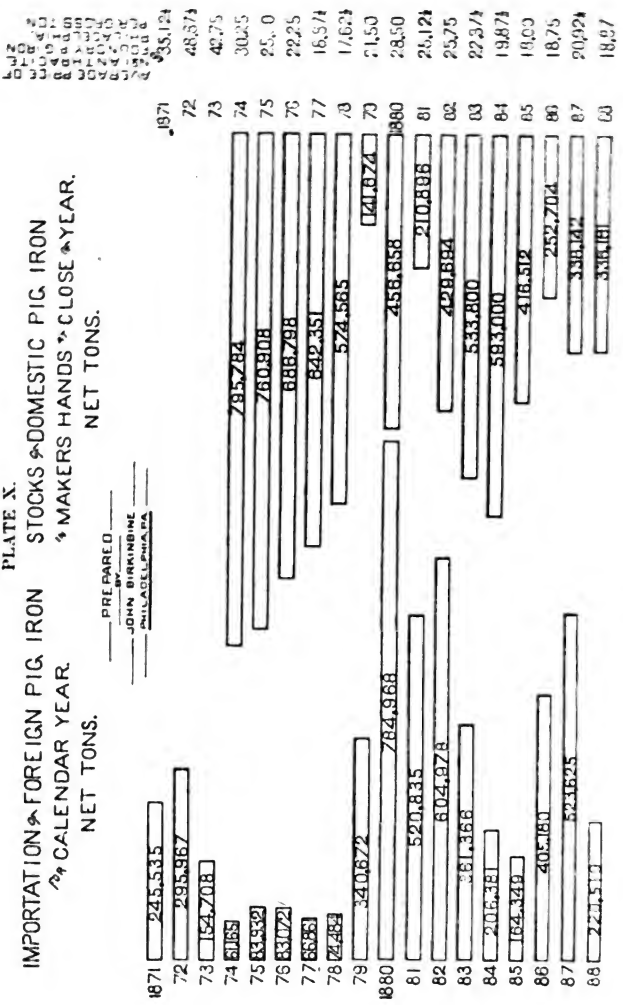

PLATE X.

IMPORTATION OF FOREIGN PIG IRON PER CALENDAR YEAR. NET TONS.

STOCKS OF DOMESTIC PIG IRON IN MAKERS HANDS AT CLOSE OF YEAR. NET TONS.

PREPARED BY JOHN BIRKINBINE PHILADELPHIA

AVERAGE PRICE OF ANTHRACITE No. 1 FOUNDRY PIG IRON PHILADELPHIA PER GROSS TON.

This is 134,866 net tons below that of the apparent consumption for the year 1887. The table above referred to* indicates clearly as far as the American pig-iron industry is concerned, that over production has not been the trouble. In fact the stock of pig-iron on hand at the close of any year since 1878, has been, with the exception of the years 1883, 1884 and 1885, considerably less than the importations during the year, and the influences which importations have upon the stock carried over is quite marked. This is well exhibited in the graphic representation [see plate X] which shows the comparative importations and stocks held over by bars representing the net tons of imported pig-iron received during each year, and the stocks of domestic pig-iron in makers' hands at the close of each year The average quotations for anthracite foundry pig-iron in Philadelphia, as published by the American Iron and Steel Association, are given to indicate the cause for increased or decreased importations.

In the eighteen years covered by the table we find that a total of 5,198,597 net tons of pig-iron were imported, the average being 288,811 net tons per annum. The maximum importation was 784,968 tons in 1880, and the minimum 61,165 net tons in 1874. From 1875 to and including 1888, 4,441,222 net tons, an average of 317,230 tons per annum of pig-iron were imported. The total stocks on hand for the same period show an aggregate of 7,169,647 net tons, a yearly average of 477,976 tons. The maximum stock on hand was reported in 1874, when the quantity [795,784 net tons] was so great as to encourage the collection of the statistics, and the stock, as will be noticed, declined constantly but slowly, owing to the continuous fall in the price of pig-iron until 1878. As, therefore, the fifteen years start with the maximum stock on hand, and minimum importations, we may obtain a fairer comparison by taking the last decade, viz, 1879 to 1888 both inclusive. The total importations in these ten years were 4,132,873 net tons, a yearly average of 413,287 tons, while the aggregate stock on hand for the same time was 3,709,241 net tons, a yearly average of 370,924 net tons.

The diagram will tell its own story, and will, we believe, point out to our readers the sensitive character of our pig-iron market. To us it demonstrates, when taken in connection with the figures in the table, * that we have not yet reached a point of over production, that our home consumption exceeds our home production, any surplus stock being traceable to that brought from foreign countries. If our appreciation of the diagram is correct it demonstrates that the pig-iron industry is not unnecessarily protected, and points to the small margin of profit in manufacturing this metal, making the industry extremely sensitive to outside competition.

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* *Vide* JOURNAL, Vol. VII., page 316.

STOCKS ON HAND.

The published statistics show that the stocks of pig-iron in makers' hands December 31, 1888, was 336,161 net tons, a decrease over 1887 of 1,981 net tons. This stock was nearly equally divided between the three classes of iron as indicated by the fuel used. The figures being 118,261 net tons of coke-iron, or 2.5 per cent. of the total make. 106,529 net tons of anthracite iron or 5.5 per cent. of the total make, and 111,371 net tons of charcoal iron or 18.6 per cent. of the total make.

The total stocks represent 4.6 per cent of the total product of pig-iron in 1888. The stocks held in various districts as above named in 1888 increased or decreased over 1887 as follows:

DISTRICTS.	Stock on hand December 31, 1888.	Increase or decrease over 1887.	Percentage of total stock.	Percentage of increase or decrease.
New England States, ...	11,266	+ 3,336	3.3	+ 42.1
Middle States, ...	165,944	−46,628	49.4	− 21.9
Southern States, ...	60,416	+22,435	18	+ 59.1
Central States, ...	95,853	+17,353	28.5	+ 22.1
Western States, ...	2,682	+ 1,523	0.8	+131.4
Total, ...	336,161	− 1,981	100.0	− 0.59

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* Net tons are used to correspond with the figures of the American Iron and Steel Association.

PRODUCTION BY STATES.

Taking now the States we find that Pennsylvania still holds first place with a product of 3,589,186 net tons, or 49.4 per cent. of the total make. This amount is approximately divided into anthracite and bituminous pig-iron, with a small quantity of charcoal iron. The output of the coke blast furnaces of Pennsylvania equals 40.8 per cent. of the total make, and 85.1 per cent. of the iron rated as "anthracite" was produced in Pennsylvania. The charcoal iron made in Pennsylvania was but 2.5 per cent. of the total make. The records of 1887 and 1888 show that Pennsylvania made 2.6 per cent. less pig iron in the last year than in the preceding year. The increase or decline according to fuel used was in coke iron an increase of 11 per cent., in anthracite iron a decline of 15.2 per cent., and in charcoal iron an increase of 27.1 per cent.

Ohio also holds its place next to Pennsylvania with a product for 1888 of 1,103,818 net tons, a gain over 1887 of 13.0 per cent. Most of the product was made with bituminous fuel, and this represents 22.8 per cent. of the total make with this fuel in the United States. The output of the Ohio charcoal furnaces in 1888 showed an increase of 17.8 per cent. over the figures of 1887, but the make was only 3.7 per cent. of the total product of the country. Pennsylvania and Ohio together made 63.6 per cent. of all the coke iron produced in the country last year, and their combined output of all kinds of pig iron represents 64.6 per cent. of the aggregate production of the United States.

Illinois follows Ohio as third in importance, its product in 1888, which is all made with coke, represents 12.2 per cent. of the coke pig-iron made in the country, and 8 per cent. of the total output of all our blast furnaces. Pennsylvania, Ohio and Illinois made in 1888 72.5 per cent. of the pig-iron of the United States.

Alabama, which in 1887 held fifth place, has advanced to fourth in rank, the gain over 1887 being 79.9 per cent. in coke iron, and the loss in charcoal iron 1.1 per cent. The total output of the State in 1888 was 53.5 per cent. greater than in 1887. Compared with the production of the country, Alabama made in 1888 6.2 per cent. of all the pig-iron, 7.5 per cent. of all the coke pig-iron, and 15.7 per cent. of the charcoal pig-iron.

Tennessee, New York, Michigan and Virginia form a group of approximately equal production, but hold places in the order named. The percentages of the total make in 1888 being as follows:

Tennessee,	**3.7 per cent.**
New York,	**3.5 " "**
Michigan,	**2.9 " "**
Virginia,	**2.7 " "**

Compared with the output in 1887 Tennessee increased its product 7 per cent.; New York declined 13.3 per cent.; Michigan remained practically the same, and Virginia advanced 12.3 per cent.

Tennessee made both coke and charcoal iron, the former representing 4.5 per cent. and the latter 8.6 per cent. of the total output of the furnaces using these fuels.

New York used anthracite, coke and charcoal, the anthracite predominating, its output being 9.6 per cent. of the anthracite pig-iron made in the country in 1888, but it is credited with but 1.1 per cent. of the coke iron and 3.3 per cent. of the charcoal iron product.

Michigan produced charcoal pig-iron only, and stands in the lead as a producer of this class of metal, having made in 1888 35.6 per cent. of all the charcoal iron in this country. In the output of charcoal iron Alabama ranks next to Michigan, with 15.7 per cent. of the total, and Wisconsin follows with 11.6 per cent. Michigan and Wisconsin combined are credited with 47.2 per cent. of all the charcoal iron made in the country in 1888.

Reviewing these figures we find that Pennsylvania is still far in advance of any other State as a pig-iron producer, ranking first in the output of both coke and anthracite metal, but taking only tenth place in the output of charcoal iron.

Michigan is the largest producer of charcoal iron.

The increased tonnage of 1888 over 1887 was greatest in Alabama, Ohio coming next.

The decline in tonnage was greatest in Pennsylvania, New Jersey coming next, but the heaviest proportionate decline was in Maryland. The output of each of the Middle States, of Wisconsin and of Missouri was notably less in 1888, than in 1887, but a decided advance is shown by Alabama, Ohio, West Virginia, Tennessee and Illinois.

It has not been considered advisable to follow the records of States which are comparatively small producers beyond the figures given in the tables.

BESSEMER PIG IRON.

The growth of the steel industry may be appreciated by the increased production of Bessemer pig-iron which in 1886 was 1,319,929 net tons or 20.7 per cent. of the total product of pig-iron; in 1887 was 1,638,907 net tons or 22.8 per cent. of the total product of pig-iron; in 1888, was 2,958,836 net tons or 40.7 per cent. of the total product of pig-iron.

Pennsylvania made 59.8 per cent. of all the Bessemer pig iron in 1888. Illinois followed with 18.0 per cent. and Ohio with 11.4 per cent. By localities, the vicinity of Chicago was the largest producer of Bessemer pig-iron with a total of 551,076 net tons. Allegheny county, Pa., comes next with 532,590 net tons, and the vicinity of Harrisburg, Pa., follows with 423,661 net tons.

CHARCOAL PIG IRON.

The output of the charcoal blast furnaces in 1888 (598,789 net tons) shows an increase of 20,607 net tons over 1887 or 3.5 per cent., while the quantity of all kinds of pig-iron made during 1888 showed an increase of 1.1 per cent. over the preceding year. An examination of the statistics shows that the record of 1888 in its output of charcoal iron was only exceed by the years 1881 and 1882.

Facing page 24 of Vol. V, of the JOURNAL, we gave a graphic illustration of the development of pig-iron manufacture with the various fuels from 1854 to 1883, inclusive, and on page 211 of Vol. VII, of the JOURNAL, a table was printed showing the quantities of pig iron made with the various fuels and the percentages of the total which each represented for the years 1854 to and including 1886. Supplementing this table we have the following data for the years 1880 to 1888, inclusive:

YEAR.	NET TONS OF 2,000 POUNDS.				PERCENTAGES OF TOTAL MAKE.		
	Anthracite.	Charcoal.	Bituminous.	Total.	Anthracite.	Charcoal.	Bituminous.
1880	1,807,651	537,558	1,950,205	4,295,414	42.09	12.51	45.40
1881	1,734,462	638,838	2,268,264	4,641,564	37.37	13.76	48.87
1882	2,012,138	**697,906**	2,438,078	5,178,122	39.44	13.48	47.08
1883	1,885,596	571,726	2,689,650	5,146,972	36.64	11.11	52.25
1884	1,586,453	458,418	2,544,742	4,589,613	34.57	9.99	44.56
1885 ...	1,454,390	399,844	2,675,635	4,529,869	32.11	8.83	59.06
1886 ...	2,099,597	459,557	3,806,174	6,365,328	32.99	7.22	59.79
1887	**2,338,389**	578,182	4,270,635	7,187,206	32.53	8.05	59.42
1888	1,925,729	598,789	**4,743,989**	**7,268,507**	26.49	8.24	**65.26**

Full-faced figures indicate the maxima.

Dividing the charcoal blast furnaces into districts as detailed in our various annual resumes of statistical data, we have the following statement:

DISTRICTS.	Pig-iron made in 1888, net tons.	Percentage of total product.	Stock on hand December 31, 1888, net tons.	Percentage of stock to product.
Northern, ...	13,256	2.2	15,916	26.3
Salisbury *, ...	47,169	7.9		
Pennsylvania, ...	15,139	2.5	7,904	52.2
Baltimore †, ...	23,137	3.9	2,875	12.4
Southern ‡, ...	149,026	24.9	16,289	10.9
Hanging Rock ‖, ...	26,568	4.4	7,289	27.5
Lake Superior, ...	283,008	47.3	44,349	15.6
Western §, ...	41,486	6.9	16,749	40.4
Totals, ...	598,789	100.0	111,371	18.6

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* The Salisbury district embraces the furnaces in Connecticut, Massachusetts and south-eastern New York.

† The Baltimore district comprises the furnaces in Maryland, Virginia and West Virginia.

‡ The Southern district embraces the furnaces of Alabama, Georgia, Tennessee, North Carolina and part of Kentucky.

‖ The Hanging Rock district, of Ohio and Kentucky.

§ The Western district, all charcoal furnaces west of the Mississippi river.

Concentration at Dannemora, Sweden, by the Wenström Magnetic Separator.

By Mr. R. A. COOK, *New Brunswick, N. J.*

At several magnetite mines in Sweden a magnetic separating machine, designed and patented by Mr. Jonas Wenström, has successfully taken the place of hand-picking.* This machine takes advantage of the quality of soft iron to become magnetic by induction. It consists of a barrel made of soft iron bars and some non-conducting material which is rotated around a stationary fixed shaft by means of a cog-wheel. Inside of the barrel on the fixed shaft is placed eccentrically a cylindrical electro-magnet provided with a number flanges between which wire is wound in such a manner that the flanges are of negative or positive polarity, being energized by a current passing through the wire coils from a small dynamo.

The bars have alternately two or three projections coming close to the polar flanges, so that each bar becomes virtually a prolongation of the magnetic poles. The ore and rock fed on top of the revolving barrel, coarse and fine together, adheres to the barrel during half a revolution, being released after it has passed the magnetic field, the non-magnetic material rolls off the barrel and falls in front of the dividing board, while the magnetic material drops off behind it.

Two sizes of this separator have been introduced, the largest size treats from six to seven tons of material per hour, the magnetization being strong enough to support pieces of ore up to seven pounds in weight and separate them from the rock. The smaller size treats from two to three tons per hour of material below three-quarter of a pound in weight. In Sweden these separators are used at the iron mines for extracting from dumps of waste material the good ore which had been missed in hand-picking or which was too fine to be picked out in that way, as well as some ore now being mined which was formerly selected by hand.

The Dannemora mine is situated in the south-western part of

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*This machine was illustrated in the JOURNAL, Vol. VIII, pages 106 and 107.

Sweden, about twenty-eight miles north of Upsala. This is probably the most celebrated iron mine in the world, both on account of the purity of its ores and the length of time it was opened, as it was mentioned as early as the year 1481. The ore is a self-fluxing magnetite with a very close grain.

Three analyses will show the purity of the ore:

Iron.	Phosphorus.	Sulphur.
58.2	.002	.017
55.7		
51.2	trace	.02

The mine is situated on the shore of a lake and though there are regular lines of attraction, the ore varies in thickness, seeming to lie in great masses along these lines rather than in a well-defined bed. The mine has been worked entirely open cut up to within a few years, but now it is worked principally by a shaft sunk by the side of the famous old open cut which is about 600 feet deep, and from the bottom of which the operatives still hoist some ore in buckets. The production is small, being only about 60,000 tons per annum, but this is because the company uses all of the ore, and offers none for sale.

The concentrating plant at the Dannemora mine consists of a Wenström separator twenty-four inches on the face and twenty-seven inches in diametor, a small dynamo and a portable engine of about five horse power which runs the separator, the bucket elevator, and a hoist which is capable of raising a car loaded with half a ton of ore. The material which is anything below fist size is dumped from a trestle at the elevator which conveys the material to the feed of the separator, and the separated rock falls through a chute into a car which is run off to the waste dump. The ore runs off into a barrel screen of steel with perforations one inch in diameter, and the pieces which go through fall into one car while the coarser fall into another. The cars are then hoisted on the elevator and run off to the place of shipment. The fine, below one inch mesh, is kept by itself, for, as all of the ore used in the Swedish charcoal blast furnaces is roasted, not more than five or ten per cent. of this fine ore can well be treated in roasting kilns, the fuel of which is the waste gas from the blast furnaces.

Four laborers and an engineer are required to run the machine to its full capacity, with a boy to pick out any pieces of ore which may have been knocked off by abrasion in handling. The men's work consists in shoveling the ore into the elevator and taking the rock and the ore in the cars to the respective shipping dumps. The separator was put up in 1886 and for the first year the plant was moved around to small waste heaps, putting over the machine. 2,000 tons of material.

In 1887 the present plant was built and running the separator intermittently during five months 5,720 tons of material was separated yielding 3.609 tons of ore and 2,111 tons of rock, or 63 per cent. of the material treated was picked out as ore.

In 1888 it ran in the same way and handled 5,167 tons of material, from which was obtained 3,923 tons of ore and 1,244 tons of rock, or 76 per cent. of ore from the material handled.

The cost of hand-picking at Dannemora previous to the introduction of this machine was 32.6 cents per ton, it now costs 9.8 cents per ton and 30 per cent. more ore is obtained from the same material. Few analyses of the ore are made, but the separated one yields 59 per cent. of iron for the coarse and 45 per cent. for the fine ore. If the fine ore was fed by itself in a different way the result would be better.

That such invention is of practical value for America is demonstrated by the fact that it is used profitably in Sweden where labor does not command more than fifty cents a day. There are other uses to which this magnetic separator has been applied profitably in Sweden. One is that of separating the pieces of iron from dirt in yards where pig-iron has been stored. or old heaps of waste where the dumpage from cupolas have been piled.

One problem the Swedish government solved to the furnace managers' satisfaction, was the use of fine ore in blast furnaces. It having been considered detrimental to the furnace to have any large quantity of fine ore, experiments were made at the government expense under the charge of an eminent Swedish engineer, Mr Granstone, in making briquettes of a mixture of fine hematites, crushed and concentrated to 65 per cent. of iron and slacked lime in a powerful brick machine. These briquettes when put in the furnace went to pieces and Mr. Granstone decided to see exactly how much fine ore a furnace would stand. Taking one of the charcoal furnaces in his charge he began by using a mixture of 10 per cent. of fine ore and gradually worked it up to 75 per cent. The only changes that he found with the latter was that the gases were hotter and he was able to carry a slightly heavier burden on the furnace, the blast pressure being the same. The conclusion was that the manufacture of briquettes was entirely unnecessary.

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Jaw Crushers.

In connection with our articles on iron-ore concentration we propose discussing the mechanical appliances for reduction of size of material, and first take up the jaw-crusher or rock-breaker, which is now so well known and extensively used. This is generally considered as having originated from the nut-cracker, but it is probable that the fact of the nut-cracker and jaw-crusher both having been introduced to the public by Eli W. Blake, has had much to do with this story of the latter's genesis. The original crusher patents have expired, but the Blake crushers are still largely used, many modifications and improvements having been introduced to make the machine more durable and efficient. The principle of the operation is, however, the same, viz: a fixed jaw with removable face and a swinging jaw, also with removable face. The swinging jaw in the Blake system is suspended from above and motion is given to it by means of pitmen and toggles, the minimum movement being at the receiving end of the jaws and the maximum motion at the discharge end. This secures capacity, but at the expense of uniformity in size of product—as will be evident from Fig. 1, which illustrates the position of the jaw and its point of suspension—the dotted line indicating the movement of the jaw face.

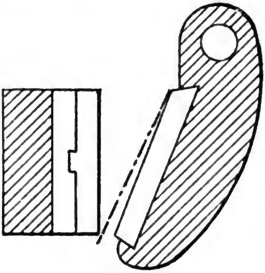

FIGURE 1.

Another form of jaw-crusher more familiar in the western than in the eastern portion of the country is known as the Dodge System, in which the jaw is pivoted at the bottom, the maximum motion being at the receiving opening and the minimum motion at the discharge opening of the jaws—encouraging uniformity of product, but with reduced capacity as compared with the crushers with jaws pivoted from above. Fig. 2 illustrates the general arrangement of the jaws on the Dodge form of crusher. The dotted line indicating the movement of the face.

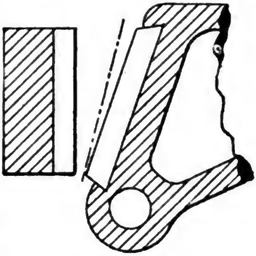

FIGURE 2.

A third form of crusher was a combination of the two above indicated, the fixed jaw common to the two systems, giving place to a movable jaw pivoted from below as on the Dodge system; the other jaw being pivoted from above as in the Blake system. Links uniting the upper portions of these jaws gave a combination of the two movements as shown by dotted lines in Figs. 1 and 2. A later modification by the same inventor of an arrangement of jaw crusher is shown by Fig. 3, where one fixed jaw is retained, the other being pivoted from below as in the Dodge system, but the pivot centre is carried back from the face of the jaw and by means of rocking arms a horizontal motion is imparted to the jaw with the object of giving the face a parallel movement as shown in Fig. 3. The Buchanan rock breaker, Fig. 3, is constructed on this principle with the object of securing both capacity and uniformity of product.

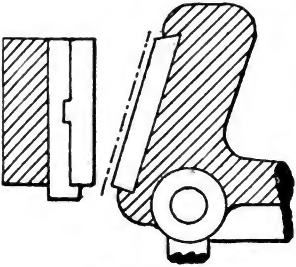

FIGURE 3.

Another form of jaw crusher is a fixed front jaw, and a movable jaw operated by a long lever arm so that one face rolls against the other, the arm working on a central pivot and the jaw traversing in an arc of a horizontal circle, while the opposite face is also on an arc. Sufficient taper is given to the jaws so that the ore which is fed vertically into the opening between them will be reduced to the size desired. The Totten crushers are of this system.

Still another form of crusher is the rotative or oscillating. This form consists of a suitable hopper of circular form in which is placed a conical jaw with a motion eccentric to the circumference of the hopper, the object being to obtain greater capacity by a continuous rotative grinding motion in place of an intermittent reciprocating motion. When this conical jaw is suspended from above it has a motion similar to the jaw of the Blake system, but when supported from below the motion corresponds with that of the jaws of the Dodge system. The Gates rock breaker is of the rotative type.

The various types above described will practically embrace all of the designs which are now in use or offered to the public, under the names of patentees or manufacturers, the means of applying power, arrangement of parts, or special features being the points of divergence. The introduction of two or more jaws as described in Vol. VIII, p. 5, is merely an adaptation of the principles above illustrated. In addition to the general forms of crushers mentioned there are a number of machines in use whereby the pieces of ore or rock are broken by being thrown at high velocities against each other so as to secure the material of desired size. These may be considered separately from the crushers in which the reduction is obtained by means of masses of iron moved so as to alternately approach and recede from others, thereby crushing the material which is fed between the moving and permanent parts.

For reducing iron ores to suitable size for concentration, the appliance adopted should be considered carefully for the amount of fines which are produced in securing a product to pass any given mesh, or the practical uniformity of the size of the material which passes the crushers is of marked importance.

The degree of fineness to which an ore will be crushed for separation, and the special machinery employed is affected:

1st. By the size of the grains or the crystals in the crude ore.

2d. By the foreign matter which is to be eliminated, and its physical condition.

3d. By the purpose for which the concentrate is to be used.

4th. By the condition of the ore, and the method employed for its separation.

If the ore to be treated is a magnetite with large crystals, or if the object of separation is to remove silicious matter only, a coarser sizing may be employed than in some other cases, for practically complete elimination of silica is not at present essential, and in some ores a system of mechanical sorting or cobbing, treating pieces from fist to walnut size may be employed. If, however, the ore is dense and the crystallization or granulation fine, or if apatite is to be removed, the reduction of size must be carried further, so far as practicable to separate each particle of magnetic oxide of iron from the other minerals, for in dephosphorization by mechanical means, a fraction of a per cent. of phosphorus will determine whether the ore will be within or outside of the Bessemer limit, and hence influence its commercial value.

The extent to which an ore is to be crushed will also be influenced by the demand for certain sizes or by the objection to others.

The condition of the crude ore will materially influence the machinery to be employed, a dry or a thoroughly wet ore being easier to manage than one that is damp or partially saturated with moisture. An experiment is to be made in crushing ore heated to such an extent as is believed will cause the minerals composing it to weaken at their cleavage planes, thus facilitating the granulation.

The problem, therefore, is to be determined specially for each ore to be treated, and consequently the particular form of crusher, whether jaw, rotative, or centrifugal, or the combination of crushers, stamps or rolls, and the system of sizing must be such as to meet the particular case under consideration.

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The traffic in 1888 through the St. Mary's ship canal connecting the waters of Lake Superior with the lower lakes amounted in value to $82,156,019 an increase of $3,000,000 over 1887. 8,411,423 tons of freight were carried through the canal in 1888, an increase over 1887 of 17 per cent. or nearly a million tons.

Among the items of freight were 2,105,041 tons of coal going west; manufactured iron going west, 48,859 tons, pig-iron, 14,844 tons, and iron ore going east, 2,570,517 tons.

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The Iron Age says that the result of investigation into the condition of the fuel supply of the Lake Superior Charcoal Furnaces is confirmatory of the statements that an undoubted shortage exists at present at a very considerable number of the furnaces. And unless this shortage can be corrected by favorable conditions during the summer there will be a shrinkage from this and other causes of 25 to 30 per cent. in the output of Lake Superior charcoal pig-iron. The low price of iron now ruling, naturally imparts a feeling of depression to the entire trade, and almost forbids a display of energy which would in any degree increase expenses.

Concentration of Iron Ores. No. 3.

In continuing the discussion of concentrating iron ores, we may properly take occasion to call attention to the increasing interest in sorting ores, picking out the rich from the lean, thus bringing up the average units of iron in an ore, and consequently enhancing its value. This interest has been developed by the demand of the blast furnaces for richer ores, by the competition in iron mining, and by the transportation charges, which are the same for a ton of lean as for a ton of rich ore. This hand-sorting has also attracted attention to the possibility of recovering good ore which was formerly wasted by being thrown on dump piles, and as a consequence considerable work is now being done by hand to secure richer or more uniform grades of ore.

For much of the following data concerning hand-sorting, we are indebted to Mr. Richard A. Parker, M. E., of Marquette. It is offered to our readers in the hope of encouraging some to improve their product, or to recover from the waste dumps valuable material.

HAND-SORTING.

The dump pile at the Republic mine in the Marquette region is now being hand-sorted, and is estimated to contain 2,000,000 tons of ore. 21,000 tons of merchantable ore were separated from this mass in 1888, which after paying 30 cents royalty, and $1.85 freight, netted the operators a profit of 50 cents a ton. The ore as shipped yielded 62 per cent. of iron, and was Bessemer in quality. About two-thirds was specular and one-third magnetic. The contractors expect to ship 40,000 tons from this pile in 1889, and it is estimated that an equal quantity can be obtained for many years to come. A similar plan of cobbing the piles in other Marquette mines is also being carried out, nearly 30,000 tons of hand-picked ore being shipped by one company formed for that purpose in the last three years. At the Champion mine in the Marquette region hand separation has been carried on for some time, but within the last eighteen months a complete system has been adopted which is giving very satisfactory results. The ore raised from the mine is either No. 1, No. 2, rock, dump or waste. The No. 1 is mine sorted and must be absolutely clean, usually carrying 66.5 per cent. of iron or above. No. 2 varies from 63.5 to 66.5 of iron. The balance of ore is carried to a sorting floor and dumped in a series of stalls. The rock and waste going directly to the waste dump piles. In each of these stalls two men and a boy have two wrought-iron cars into which the ore is carefully spread with a shovel, and the various grades picked out by the use of the hand and eye only. Some of this ore sorted from the stalls is No. 1 "Champion," some No. 2 "Chelsea," and two inferior grades are produced, "Suffolk" carrying 60 to 63.5 per cent. of iron, and No. 4 "Norfolk" yielding 57 to 60 per cent. of iron. To indicate how close this hand-sorting can be carried, two cargoes were sold as being of "Norfolk" grade to yield 57 per cent. of iron; the actual sampling of the ore after delivery showed for the two cargoes 57.09 and 57.12 respectively. In six months, July 1st to December 31st, 1888, about 43,000 tons of material were thus hand-sorted, the percentages of the various grades being as follows:

No. 1, 17 per cent.; No. 2, 11 per cent.; No. 3, 31 per cent.; No. 4, 16 per cent.; rock, which includes everything below the "Norfolk" grade, 25 per cent. The quantity of material handled per man per day is approximately 7 gross tons, from which about 5 gross tons are selected at an average cost of 38.6 cents for labor. The price paid per ton for selected ore varies according to grade, a larger sum being naturally paid for the richer ores than the leaner grades. The average rate of wages paid per day during the time above mentioned was $1.75.

The perfection of the system of hand-sorting is due to the plan of organization, and also to the thorough inspection by skilled assistants, whose compensation is made up by assessing the various contractors in proportion to the amounts of ore they deliver. We note the close approximation of the cost of hand-sorting as given above to the figures which prevailed in Sweden as given by Mr. Cook in describing the operation of the Wenström magnetic separator at the Dannemora mines (Sweden) in this issue. But even if hand-sorting was much reduced in cost, there is a limit to which it can be carried, and much ore must necessarily be wasted at mines removed from blast furnaces, which could be smelted close at hand. In a majority of cases such ore must be subjected to some method of concentration, and whether the wet or the dry process is attempted a preliminary comminution must result. We have referred in these articles to the use of concentrated ore, and now add other data upon this subject:

USE OF FINELY DIVIDED ORE.

Mr. E. S. Moffat supplies the following figures as the amount of separated ore used at the furnaces of the Lackawanna Iron and Coal Co., at Scranton, Pa.:

In 1886, 4,445 gross tons; in 1887, 8,765 gross tons; in 1888, 22,173 gross tons. And Mr. A. L. Inman, General Manager Chateaugay Ore and Iron Company, furnishes the following data: "Prior to 1886 he made separated ore in a comparatively small way, which was used in the production of blooms, but in 1886, we commenced its production with more vigor, making, in 1886, 23,885 tons, in 1887, 47,324 tons, and in 1888, 54,048 tons."

These figures would indicate that a market is being found for this finely comminuted ore. The holes in the screens at the separating plant of the Chateaugay Ore and Iron Company, at Lyon Mountain, N. Y., are five-sixteenths of an inch in diameter, but necessarily a large portion of the material is much finer. A hand trial of the crushed ore before it passed to the jigs showed the average to be thirty mesh; of the total amount only fourteen per cent. by weight remained on a four mesh sieve, and less than one half of the entire material was held in a screen of sixteen meshes to the inch. 8.3 per cent. passed through one hundred or finer mesh screens.

We may naturally expect that as a rule blast furnace managers will object to the fine material, but it is questionable whether many of the ores now used succesfully in the blast furnace, are not as finely divided as separated ores. The softer hematites, which may be shoveled up like mud, undoubtedly are speedily converted into sand by drying out in the shaft of the blast furnace.

These soft hematite ores are much esteemed by the blast furnace managers of the North-west, and where the desire is to drive a furnace, the lump ore is often discarded for this fine material; therefore, independently of the character of the ore we may consider its finely divided state to be such as should commend rather than condemn it for blast furnace use.

Mr. E. S. Moffat, General Manager of the Lackawanna Coal and

Iron Company, to whom reference is made above, has done much to demonstrate the practicability of using concentrated ores, and to the success which he has had is probably due the effort of the company he represents to produce their own concentrates by the erection of a concentrating plant which differs materially from those which were illustrated in parts 1 and 2 of the discussion on Iron Ore Concentration, particularly in the manner of reducing the ore to the sizes required. This plant, lately erected by the Lackawanna Coal and Iron Company, at the Tilly Foster Mines, in Putnam county, New York, was designed to treat the leaner magnetic ore which is taken out of the mine and also the accumulated waste dump pile which represents some 80,000 tons. It is at this mine that the owners are uncovering the pillars left to sustain the hanging wall to depths of from two hundred to three hundred feet, thus handling 300,000 cubic yards of rock. The company anticipate thus securing 600,000 tons of ore of which probably 500,000 tons can be shipped as mined, the balance going to the concentrating works. As the operation up to the present has been experimental only, we give no results, but content ourselves with a general description of the plant.

CONCENTRATING MILL AT TILLY FOSTER MINE, NEW YORK.

The concentrating works are located on the side hill close to the mine, and form one large frame building which is practically divided into three parts, namely a boiler and engine house, forty by forty-five feet, and sixteen feet high, a crusher house forty feet by forty-five feet and fifty-four feet high, and a jig house forty-five by forty-five feet and twenty-six feet high. In the engine and boiler room are located three locomotive type boilers fifty-four inches in diameter, twenty-seven feet long, each rated as one hundred horse power, and a horizontal steam engine with steam cylinders fifteen inches by twenty-four inches which furnishes power to the mill through a main pulley eight feet in diameter on which runs a twenty inch belt. This engine is rated at one hundred and twenty-five horse power.

The ore comes to the concentrating works on standard gauge flat cars with drop bottom. The ore being discharged onto a "grizzly" made of railroad iron, the fines passing into a bin, the coarser ore being fed into a fifteen by twenty Blake crusher, which reduces the ore to about three and a-half inches in size; the material from the crusher also passing into the bin. From the bin the ore is fed under the rams of two Ball stamps. These, as many of our readers are aware, are practically vertical steam hammers, the admission of steam being controlled, and the number of strokes therefore regulated, by a belt from the shafting of the plant. The cylinders of these stamps are 15 inches in diameter by 26 inches stroke, and the weight of the moving parts is 4,300 pounds.

These stamps are set up on heavy timber foundations, forming a solid frame work sixteen feet square and twelve feet deep, on which are placed iron beams, and a timber cushion under the pan. When visited the stamps were making 75 strokes per minute, reducing the ore so as to pass through holes three-eighth inch in diameter in steel plates. The material from under the stamps is run into an iron boot in a cemented tank built below the floor level, from which it is elevated by buckets secured to a belt, and washed to remove the talcose material which interferes with successful jigging From the washer the pulp is again elevated into wooden tanks, and from these fed to five Conkling jigs of the design shown on page 8, Vol. VIII, the tails being carried away from the building by suitable spouts, and the concentrates elevated into a receiving tank, at the side of which runs a conveyor for automatically loading the product into cars.

The volume of water required for this plant is quite large, and is obtained by pumping from one of the reservoirs of the Croton water works system adjacent to the mines. The water is returned to this reservoir from the concentrating plant.

For treating lean ores, particularly magnetites, we believe that magnetic separation is decidedly preferable to jigging, but in either method a careful study of the ore is essential to success.

MAGNETIC CONCENTRATION.

The number of experiments now being made with apparatus in which magnetism is used as a medium for separating iron ores will shortly bring results which will demonstrate its value. These experiments are being made upon various magnetic iron ores, as well as upon some hematites which have been subjected to heat to change the sesquioxide into magnetic oxide of iron.

While in some ores magnetic concentration which answers most economical purposes may be readily made, the physical structure of other ores prevents attaining a separation approaching perfections. In one New York State magnetite a microscopic examination which Mr. E. K. Landis made of the ore after it passed the crushers, rolls and screens showed that however fine the grain, it, in many cases, consisted of molecules of $Fe_3 O_4$, SiO_2, FeS, and hornblende, pieces about one one-hundredth of an inch showing under the microscope, magnetite, pyrite, quartz and sometimes hornblende.

Dr. Eugene Hussak in his monograph on "The determination of rock forming minerals," says if several ferriferous minerals occur in the rock to be examined, *i. e.*, magnetite, ilmenite, augite, biotite, olivine, etc., they can be separated from each other by varying the strength of the current passing through the electro-magnet. At first two elements are used, then four, six, eight and finally ten. Doelter has shown that the minerals can be arranged in a series according to their power of being attracted. He gives thirty-three minerals and indicates their order in the power of being attracted by magnets.

Dana says magnetite is strongly magnetic, and sometimes possess polarity, and that from the normal proportions of one part of Fe O to one of $Fe_2 O_3$ there is occasionally a wide variation, and thus a gradual passing to the sesquioxide [$Fe_2 O_3$]; he instances analyses from Bengal, India, in which the proportion of $Fe_2 O_3$ to FeO was nearly three to one, in an ore which was strongly magnetic and columnar, while another ore from the same locality in which the proportion of $Fe_2 O_3$ to FeO was in the proportion of three and a quarter to one was granular, and not polar magnetic. He also says that hematite is sometimes attracted by a magnet, and occasionally even magneti-polar. Martite which is supposed to be a psuedomorph, mostly after magnetite is reported as non-magnetic or only feebly so. Menacanite slightly influences the magnetic needle.

The presence of certain of these minerals will materially affect the results obtained, as we naturally look for a better separation when the material in the gangue is but slightly attracted by the magnet or practically insensible to its influence.

In the *Transactions of the American Institute of Mining En-*

gineers, Vol. IX, page 451, Mr. Ellis Clark, Jr., described a magnetic separator in use at Pribram, Bohemia, in which zinc blende is separated from spathic iron ore previously roasted to make it magnetic, and reduced to grains less than one m. m., probably 25 mesh.

In the JOURNAL, Vol. IV, pages 324–7, there appears a description of a concentrating plant for the treatment of magnetic iron ores; the ore being reduced by a crusher and two pair of rolls, sized by appropriate screens, the product being concentrated by means of Buchanan magnetic rolls, and by water jigging. This paper is accompanied by plates showing the arrangement of the mill which can, with propriety, be consulted in connection with the concentrating plant 5, on pages 4 to 13, Vol. VIII, and with the plant described in this number of the JOURNAL.

THE EDISON SEPARATOR AT HUMBOLDT, MICHIGAN.

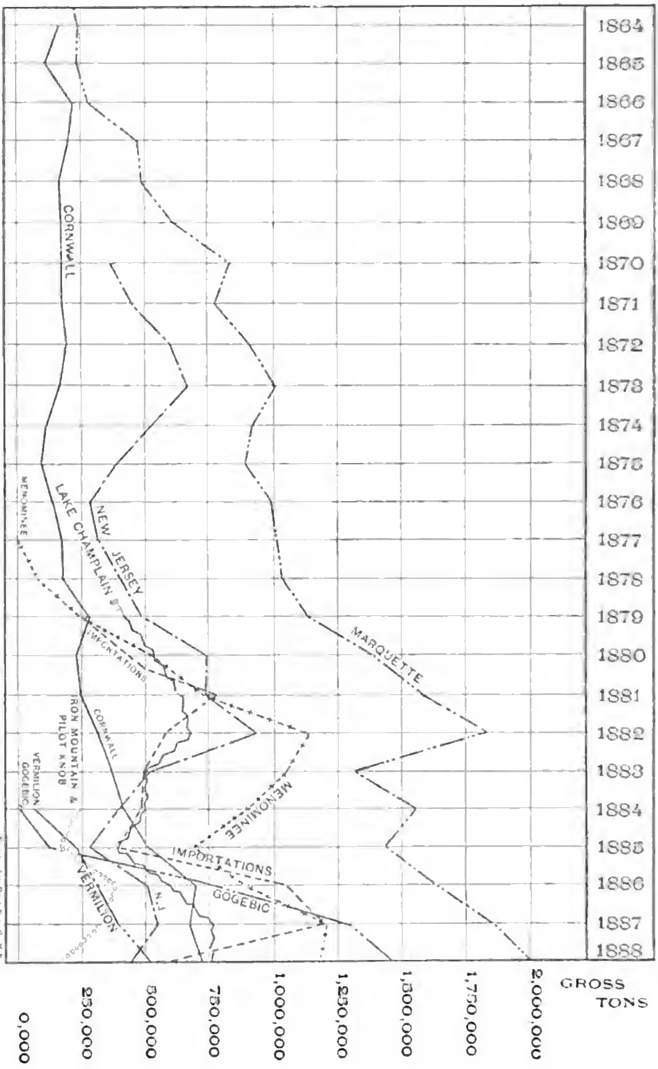
A very interesting experiment is now being made at Humboldt, Michigan, by working over the dump-pile of the Samson mine, and passing it through an Edison uni-polar separator such as was described in the JOURNAL, Vol. VIII, page 100. The ore is taken to the concentrating plant and passed through a No. 3. Gates crusher, the crushed ore falling on a double-shaking screen; all of the material which passes the upper or coarse screen is fed to a pair of 30 inch by 16 inch Cornish rolls, while that which is refused by the screen is returned to the crusher. The material which passes through the lower or finer screen drops into a bin where it mingles with the product of the rolls; a second screening separates any coarse material and this is returned to the rolls, while the finished product is elevated to a hopper over the magnet. From this hopper the ore passes in front of the magnet, the concentrates being deflected into one bin and the tailings into another, while the "mugwump" or such material as does not go into either bin, for the reasons before given, returns to the finished product bin and passes again before the magnet.

This experimental plant has lately been started and it is expected that by the time the next issue of the JOURNAL appears some interesting data will be obtainable.

JOURNAL OF THE UNITED STATES ASSOCIATION OF CHARCOAL IRON WORKERS.

VOL. VIII.—NO. 3.

PLATE XI.



COMPARATIVE RECORD OF OUTPUT OF IRON-ORE DISTRICTS OF THE UNITED STATES.

Eng'd by Am. Bank Note Co. N.Y.

Messrs. Witherbees, Sherman & Co., are experimenting with various magnetic separators at their mines, near Port Henry, New York, and the remodelled mill at the Croton mines, near Brewster, New York, will soon be ready for operation. Plants for magnetic concentration by the use of the Edison Separator are also being erected in Eastern Pennsylvania.

Where Our Iron Ore Comes From.

The knowledge concerning certain iron ore deposits which has become general through the fact that they are located convenient to some of our prominent iron producing centres, or by reason of having been worked for many years has led to a misapprehension of the true relations which our prominent sources of iron ore supply have to each other. To properly present this matter the editor prepared for the *Transactions of the American Institute of Mining Engineers* a monograph accompanied by a graphic representation a reproduction of which we herewith present by the courtesy of the Secretary of the Institute. We believe an examination of plate XI will be a surprise to many of our readers by demonstrating the relative importance of some of our iron ore deposits. It is a source of regret that the destruction of books of record by fire prevents tracing the output of the Lake Champlain and the Southern Missouri mines through longer periods, for the plate does not indicate the important position that has been held by these localities for many years. Some sources which now produce a small proportion of the ore used, have, in the aggregate, added very largely to the material wealth of the country, and have been of great service in the development of our iron industries.

The estimated production of iron ore throughout the world in the year 1888 was, in round numbers, 50,000,000 gross tons, of which the United States contributed about one-fourth. Great Britain leads this country in production by about fifteen per cent. but the output of the United States is practically equal to that of Spain, France, Russia, Austria and Hungary combined. Foreign ore was imported into this country in 1888 to the amount of 587,470 gross tons. A close approximate of the amount of iron ore consumed in the United States in 1888 in its blast furnaces, rolling mills, and for other purposes is 12,700,000 gross tons.

The Lake Superior region is by far the largest producer of iron ores in the United States. The total output for 1888 was 5,023,279 gross tons equivalent to about forty per cent. of all the iron ores mined in the country. The entire output of this interesting region is very close to 41,000,000 tons, divided as follows: The Marquette range produced from 1854 to, and including 1888, 27,130,419 tons, the Menominee range from 1877 to, and including 1888, yielded 8,594,037 tons, the Gogebic range from 1884 to 1888 inclusive, is credited with a product of 3,586,876 tons. and the Vermilion range in Minnesota has shipped from 1884 to, and including 1888, 1,498,209 tons. We, therefore, find that of the total amount of ore won from the Lake Superior region, the Marquette range has contributed 66.5 per cent., the Menominee range 21.00 per cent., the Gogebic range 8.8 per cent, and the Vermilion range 3.7 per cent.

The year 1888 shows a larger output for the Marquette range than any other year since its opening, the increase over 1887 being 61,482 tons, and out of the seventy-four mines on the Marquette range forty-one were active, producing 1,921,525 tons of iron ore, equivalent to 38.3 per cent. of the 1888 product of the Lake Superior region. Out of these active mines, three produced over 200,000 tons each, three between 100,000 and 200,000 tons, and five between 50,000 and 100,000 tons.

The Menominee range contributed 34,304 tons less in 1888 than it did in 1887, the total for 1888 being 1,165,039 tons obtained from twenty-two mines out of thirty-six on the lists. Of these mines one exceeded an output of 200,000 tons, four produced between 100,000 and 200,000 tons, and four gave products of between 50,000 and 100,000 tons. The Menominee range yielded 23.2 per cent. of the total of the Lake Superior product for 1888.

The Gogebic range which, in 1887 outstripped the Menominee range and took second place as a producer, excelled its previous record by 134,497 tons, producing a total of 1,424,762 in 1888, or 28.9 per cent. of the Lake Superior output. This ore came from twenty-one mines out of a total of thirty-four on the list, one of which yielded in 1888 over 400,000 tons, and one over 200,000 tons, two over 100,000 tons, and three produced 50,000 tons and over.

The Vermilion range also reached its largest output in 1888, namely 511,953 tons, or an increase over 1887 of 117,701 tons, and this range is credited with 10.1 per cent. of the total Lake Superior product for last year. There are but two mining companies on the range, one of which contributed 457,000 odd tons and the other 55,000 tons.

The figures herein given demonstrate the extent to which iron ore mining has been carried in the Lake Superior region, and the volume of ore handled is the more remarkable when the high percentages of iron in the ores is considered. The greater portion of the ores mined are red hematites, varying from the soft to the hard specular varieties, but some magnetites are obtained, and in a few deposits the hydrated condition of the ore places some of it in, or close to the limits of brown hematite. The distance from these mines to blast furnaces, and the expense of transportation makes it necessary that a standard of quality should be maintained which is above the requirements of most of the other iron producing districts. This standard may be considered as approximating a yield of sixty per cent. of iron when dried at two hundred and twelve degrees, but many ores exceed this requirement.

The Cornwall ore banks, in Pennsylvania, contributed to the supply of iron ore for the year 1888, 722,921 gross tons, an amount greater than ever taken out in one year from this deposit, which has been operated for one hundred and fifty years and produced an aggregate of 9,395,923 gross tons of iron ore.

The development of this property has naturally been stimulated by the advance in iron production, for the deposit had not yielded a half million tons in any year until 1885, and 1879 was the first year that over a quarter of a million tons were mined. Within the past decade a total of 4,421,000 tons were obtained, this is equivalent to nearly one-half of the aggregate output of the Cornwall ore hills. The ease with which soft magnetites are mined from the Cornwall ore hills and the convenience of the deposit to fuel supply and to blast furnaces would permit of a still greater output if efforts were made to distribute the ore over a larger area than is now the case. It is, however, equitable in comparing the Cornwall ore hills with the Lake Superior region to note the fact that the ore which yields about the same per cent. of iron as the Cornwall ore is carried to the waste piles at many of the Lake Superior mines, and an output of 575,000 to 600,000 tons of the average Lake Superior ore as shipped, would produce as much iron as the 723,000 tons taken from the Cornwall ore hills. The sulphur and copper in the Cornwall ore does not interfere with its use in producing Bessemer iron, the former being generally reduced by roasting with solid fuel in the Gjers and Grittinger kilns. Lately the Davis Colby kiln has been applied, and waste gases from the blast furnace employed as fuel. The percentage of copper is not sufficient to materially influence the use of the ore.

Some of the Lake Champlain deposits have been operated for nearly a century, and others were opened at later dates. The total output of this district to date is estimated at 15,147,000 gross tons, of which 5,794,000 gross tons have been mined within the last decade. The largest producers are the mines at Mineville near Port Henry, from which 9,150,000 gross tons are estimated to have been obtained. The total production of the Lake Champlain district in 1888 was obtained as follows:

From mines near Port Henry, New York, . .	419,009	gross tons.
“ “ of Chateaugay Ore and Iron Co.,	250,500	“ “
“ “ near Crown Point, ...	74,910	“ “
“ other mines, estimated, ...	45,000	“ “
Total, ...	789,419	“ “

This makes the Lake Champlain district outrank the Cornwall for the year.

New Jersey fell considerably behind former years in 1888, the total being 447,738 gross tons, as against 547,889 gross tons mined in 1887. The aggregate product of the New Jersey mines since their opening, dating back into the last century is estimated at 16,500,000 gross tons.

A district which has become quite prominent as an iron ore producer is that portion of Missouri in which the Iron Mountain and Pilot Knob are located, but the quantity of ore that has been obtained from this district has lately been less than is generally supposed. The total amount shipped in 1888 was 160,000 gross tons, and the forty or more years in which iron has been taken from this district a total of about 4,000,000 tons has been obtained, of which seventy per cent. came from Iron Mountain.

We are only able to form an approximation of the ore used in the Southern States based on the pig-iron output for the year, allowance being made for shipments of ore from one State to another. A calculation made in this way shows that in 1886 the States of Virginia, North Carolina, Georgia, Alabama, Tennessee and Kentucky produced about one and three quarter million gross tons, while in 1887 the output of the mines slightly exceeded two million tons. The consumption of ore in these States in 1888 approximated 2,500,000 gross tons. Of this amount fully seventy per cent. was red hematite or fossil ore, about twenty-five per cent. brown hematites, and probably about five per cent. magnetite. Alabama contributed about 1,009,000 gross tons, Tennessee is estimated to have supplied 615,000 gross tons, and Virginia between 450,000 and 500,000 tons.

Authentic records of the quantity of iron ore imported are not obtainable, except, since the year 1879, but these figures show that in the past ten years an aggregate of 6,340,062 gross tons of iron ore were brought into the United States from foreign countries.

From the foregoing data it is possible to arrange the various sources of iron ore supply according to their amounts of ore produced in 1888. It is not claimed that the relative order or the quantities are absolutely correct but they are as nearly so as it is possible to make them without actual returns from numerous small mines.

RELATIVE IMPORTANCE OF VARIOUS DISTRICTS IN 1888.

Order	Name.	Gross tons mined in 1888.
1.	Marquette range, Lake Superior region,	1,921,525
2.	Gogebic " " " "	1,424,762
3.	Menominee " " " "	1,165,039
4.	Alabama, (estimated,)	1,000,000
5.	Lake Champlain district, New York,	789,419
6.	Cornwall ore hills, Pennsylvania,	722,921
7.	Other Pennsylvania mines, (estimated,)*	700,000
8.	Tennessee, (estimated,)	615,000
9.	Foreign ores,	587,420
10.	Vermilion range, Lake Superior region,	511,953
11.	Virginia, (estimated,)	450,000
12.	New Jersey,	447,738
13.	Missouri,†	160,000

The important position which various districts hold as contributors to our mineral wealth will also appear from the total amount of ore which is estimated to have been taken from them, thus:

---

* The total output of Pennsylvania, including the Cornwall ore hills, would probably make that State rank as third.

† Shipments from Iron Mountain and Pilot Knob only.

TOTAL ESTIMATED OUTPUT TO DATE.

Marquette range, Lake Superior district, .	27,130,419	gross tons.
New Jersey, (estimated,)	16,500,000	" "
Lake Champlain district, ...	15,147,000	" "
Cornwall ore hills, ...	9,395,923	" "
Menominee range, Lake Superior district,	8,594,037	" "
Iron Mountain and Pilot Knob, Missouri,	4,000,000	" "
Gogebic range, Lake Superior district, . .	3,586,876	" "
Vermilion range, Lake Superior district,	1,498,209	" "

The above amounts are merely presented to indicate the quantities taken from such sources as could be traced. In comparing them time must be a factor, for iron mining has been followed for many years in the Lake Champlain district, in New Jersey, at the Cornwall ore hills, etc., while the Menominee range is but eleven and the Gogebic and the Vermilion but five years old.

Analysis of Iron Ore Used at the Ilsede Furnace, Germany.

In the current volume of the JOURNAL, pages 64–5, we gave tables of the operation of the Ilsede furnace at Gross Ilsede, Germany, and also of the items of cost which enable these furnaces to produce iron at unusually low rates, the minimum per metric ton being for 1887, $5.52, equivalent to $5.61 per gross ton. We are now enabled to give the analyses of the ores used which were published in *Stahl und Eisen*, Vol. VIII, p. 368:

	Adenstedt Argillaceous ore.	Mathilde Argillaceous ore.	Mathilde Calcareous ore.	Bulten Calcareous ore.	Bulten washed ore.	Mathilde washed ore.	Georg Friedrich ore.
Silica, ...	8.74	10.17	7.88	4.42	4.74	6.27	22.97
Alumina, ...	3.57	3.36	3.71	0.82	5.58	5.43	5.26
Oxide of iron (Fe^2O^3), ...	57.92	59.43	49.16	47.10	54.46	60.87	52.99
Oxide of manganese (Mn^2O^3), . .	10.32	1.28	1.34	7.15	9.28	0.83	0.62
Lime, ...	6.28	8.21	15.58	17.03	7.97	7.48	3.21
Magnesia, ...	0.74	0.69	0.52	0.65	. . .	0.57	0.22
Phosphoric acid, ...	2.65	4.41	3.76	2.68	3.21	4.63	1.64
Loss on ignition, ...	9.84	11.99	17.18	20.03	14.58	13.55	12.83
Iron, ...	40.54	41.99	34.41	32.97	38.11	42.61	37.06
Manganese, ...	6.52	0.80	0.84	4.57	5.86	0.52	0.39
Phosphorus, ...	1.15	1.95	1.64	1.17	1.40	2.02	0.72

Electrical vs. Rope Transmission of Power.

Of the several methods of transmitting power to a distance, that by means of wire ropes has usually been referred to as the most economical for moderate distances, and the success of the rope transmission, which for many years has been in operation at the Falls of Schaffhausen, on the Rhine, has been cited as justifying this opinion. It seems that hereafter the plant is to furnish a demonstration of the superiority of electric transmission. A correspondent of *Industries* says that:

"After two years of negotiations, the company who own the Schaffhausen teledynamic transmission plant have at last succeeded in overcoming the obstacles, legal and otherwise, which hitherto stood in the way of an extension of their system, and they are now erecting five more turbines on the left bank of the Rhine below those now at work. The water for actuating these turbines will not be taken from the Rhine fall, but it is part of water now running to waste over a weir of 600 feet in length, the concession for which was obtained by the company in 1863. Each of the new turbines will be of 300 horse-power, the total quantity of water available being 40 tons per second, with a fall of 13 feet. Instead of using teledynamic transmission, such as is employed in the other station, the company propose to use electric transmission of energy. There will be dynamos at the turbine station, and cables stretched across the river, by which the current will be carried into Schaffhausen, and there used to actuate electromotors.".

The substitution of electric transmission for the compressed air at the Chapin mine, Michigan, is now admitted to be desirable from an economic standpoint, and this is, with the exception of the Birmingham, England, compressed air system, the largest plant of the kind in the world.

It would seem, therefore, that electrical transmission of energy is destined to supersede both wire rope and compressed air transmission, except, possibly, under circumstances which are specially favorable to the latter while unsuitable to the former. The results of experiments, as shown by the actual substitution of one system for the other, outweigh all arguments based on fine mathematical calculations, or on theoretical deductions, and we, therefore, attach special importance to this announcement.—*Exchange.*

Book Notices.

Messrs. Robert Clarke & Co., of Cincinnati, Ohio, have issued a new publication entitled "Economic Value of Electric Light and Power," by A. R. Foote, 12mo., bound in vellum cloth. The price is $1.00.

In this book the author devotes a large share of attention to the electric service as applied to cities and towns, but incidentally takes up the electric moter, the arc and incandescent lamps, the economy of electric lights versus other lights, the transmission of power, etc., and in the appendix there is a valuable glossary of mechanical and electrical terms, explained in elementary language which must be of service to parties who are looking into the economy of electricity either for light or power, in furnaces, mills or mines.—EDITOR.

◆

THE new bed at Mineville, Essex county, N. Y., operated by Messrs. Witherbees, Sherman & Co., has lately been producing from numerous openings iron ore of such remarkable purity as to be a wonder even to those familiar with that unique deposit of Bessmer iron ore. A sample taken so as to represent the average of a pile of about four hundred tons was submitted to the company's chemist, Mr. T. R. Woodbridge, who found that it contained 72 per cent. of iron, and 0.018 per cent. of phosphorus. Similar pockets of such ore have occasionally been found in the new bed, and from these pockets are often obtained unique crystals of magnetite, some of them two inches or more on face. In the company's office at the mines is a perfect octahedral crystal, one and a quarter inches on the face, which can be readily lifted from its socket in a matrix of granular ore.

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To meet the demand for complete volumes of the JOURNAL, the publishers have depleted the stock of certain numbers, so that it is considered advisable to direct attention to the fact that unless additional copies of some of the issues can be obtained, but few more complete sets can be supplied at the prices named in the advertisements. The numbers which at present are scarce and for which compensation in exchanges or in money will be paid are:

Vol. I., No. 1, June, 1880.
Vol. I., No. 2, August, 1880.

THE EDITOR.

Blast-Furnace Management.

To one who carefully studies the operation of American blast-furnaces there appear many conditions which help to make up the causes of success or failure attending the efforts of individual managers; for it is not alone to the person who has actual or apparent charge of a furnace plant that results are attributable. There are good and bad managers and there are good and bad principals who either help or retard their subordinates.

The credit of the wonderful advance made in American blast-furnace practice is very largely attributable to the managers of our furnace plants, and we know of individual instances where even better results would have followed had the managers been properly sustained by the owners or directors of iron-works. On the other hand, cases could be cited where the management of blast-furnaces is such as to materially restrict, if not to ultimately cripple, the works.

We have before asserted that eternal vigilance is the price of success in blast-furnace practice—but unless such vigilance is properly recognized and sustained by those who really control the policy of the organization, only partial success at best can be secured. If a blast-furnace manager obtains good results with a poorly equipped plant, or by the use of imperfectly prepared stock, we may naturally expect that better returns would follow the adoption of such improvements in plant or material as a policy of true economy may dictate.

A manager who with meagre facilities accomplishes satisfactory results for his principals, is fairly entitled to be consulted concerning possibilities of better operation from modern structures or improved materials. We, however, recognize in some iron-works a parsimony (which is mistaken for economy) by the owners that restricts the management and forces a contention with disadvantages which could be readily removed if a liberal spirit pervaded the controlling power.

On the other hand, there are managers so wedded to ancient traditions and practice—so averse to attempting, or even studying the merits of modern plants or methods—that notwithstanding a desire and intention on the part of the owners to keep up with progress made elsewhere, the plants are falling behind in the sharp competition of to-day. These fossil managers are constantly hunting for excuses for the good work of others rather than studying to find out why they fail to accomplish equally satisfactory operation. If they only had the rich ore which A has, or if their fuel was as good as B uses, or if C made as good an iron as they do (although both may command the same price in common markets and thus be commercially on an equality), or if they had a new furnace like D, or if E did not scrap his furnace so heavily—the results, they claim, would be nearer what they obtain.

We are not among those who see in the near future a necessary and radical geographical change in the location of the iron-producing industry beyond what the natural movement of population and business will encourage. While certain sections of the country are developing more rapidly than others, we must remember that the whole country is growing, and with this growth the demand for iron and steel is augmenting in even greater ratio than the population by reason of new adaptations. The eleventh census will undoubtedly indicate a larger consumption of iron per capita than the census of 1880.

There is, therefore, work for the old as well as for the new plants, unless the patriarchs refuse to meet the advances made by the younger enterprises. The older districts have several advantages which give them a strong position. Established trade, convenient markets, abundant labor, ample capital and little or no interest to pay on investment, are matters of grave importance to be overcome by new plants, which must establish a trade, force the product into distant markets, train labor and pay large interest on bonds; and these obstacles can only be overcome by improved constructions and advanced practice.

If the older enterprises are content to follow in well worn ruts because the original proprietors (often the ancestors of present owners) accumulated wealth thereby, and if the direction, or management, or both, fail to take advantage of the changed conditions of trade, they must expect to be crowded out, and crowded out they will be. There are a few localities or special works possessing unusual facilities which may for a time apparently be unaffected, but the time will come when they, too, must succumb.

Instead of complaining that other furnaces have richer ore, the management and directors of these older established plants need to abandon the practice of buying rock, clay, sand or gravel as ore. A large proportion of the local supplies of ore used at many of these plants can be enriched with economy, or high grade ore used advantageously as mixtures. A careful study of the chemical and physical characteristics of the fuel used will assist greatly in obtaining better results. While it may be impracticable or injudicious to entirely remodel some of the older plants, there are few but what can be materially helped by the addition of some of the features which assist the newer furnaces to be such active competitors.

To continue in the march of progress, we must "keep up with the procession," and we believe that success depends more upon the administration and management of our American blast-furnaces than upon mere geographical lines. With ores and fuel so liberally distributed, there is little excuse for failure of established industries, except in comparatively few instances, and the sooner these few are relegated to the scrap-pile, the better for the owners and for the iron-trade generally.

The active, energetic, vigilant and studious blast-furnace manager, who is properly sustained by a progressive and intelligent ownership, will maintain the trade of an established industry. But ultra-conservatism, inefficient management, or absence of studiousness on the part of owners or managers, will soon send trade elsewhere.

Some of our readers may consider our criticisms severe; this they may be, but there is no wish to make them ungenerous. On the contrary, the JOURNAL has always been, and will continue, a champion of good blast-furnace administration, and intelligent, efficient management; ready to chronicle results obtained and glory in progress made. But we are wearied by prophets of evil, and chronic fault-finders, who with a microscope seek apologies for others' successes, but whose beam-obstructed visions fail to show the wasteful methods, poor equipment, or unbusiness-like policies which hold their own works in the background. That our criticisms are not groundless will appear from the following, to which we might add, if it were necessary.

We know of one plant well situated for obtaining an abundance of good ore from the owners' mines, which was blown out twice and banked down five or six times in a year for want of ore, and the material furnished was very imperfectly prepared. Another furnace, operated by a corporation with ample capital, has the reputation of receiving a large part of its burden from ores refused by other furnaces, which are bought under the supposition that they are cheap. We could instance a manager who asserted with candor that he doubted if good chilling car-wheel metal could be made if anything but the wooden blowing-tubs and open tuyeres were used, and another was positive that no furnace would work well with charcoal which had not the old saucer-shaped boshes. A man, whose title was general manager of a blast-furnace, suggested to his superintendent the propriety of sweeping out the inside of hot blast-pipes while the oven was cooled down to clean the outside of the pipes and repair some leaks. We need not repeat similar statements to emphasize our assertion that some of the older established furnaces have more to fear from their owners or managers than from any new competition. We note others improving their plants, securing better prepared ores, or enriching the mixtures, studying the fuel problem with care, the direction of the operations being confided to intelligent, progressive managers, who are sustained by the owners. These last are not the furnaces which are expected to be speedily wiped out of existence.

We are not slow to recognize the rapid advance being made in comparatively new sections, and we rejoice to see a proper development of local resources and the establishment of new industries, but in some of these districts the most foolish predictions are made—predictions which can only be explained by gross ignorance or falsehood, and which will result in injury to the sections whose praise is sounded. The race for pre-eminence is not to be a one-sided affair. We have pointed out some weak points which prevail among a portion of the older established plants, and indicated what we believe to be a remedy. The newer plants must be equally vigilant and progressive, for a modern construction can, under inefficient management, lose as much money for its owners as an ancient works; imperfectly prepared ores or unsatisfactory fuel are as costly and troublesome in one section as another, and a furnace plant which has no working capital and interest on a heavy debt to meet, is as certain of failure in one part of the country as in another, whether the original projectors make money off a contingent land speculation or not.

In the battle for supremacy we will have the "survival of the fittest," and the plants that can be made to be among those which are "fit" to survive will be those where the administration and management is progressive and vigilant.

Roasting Sulphurous Iron-Ore.

THE JOURNAL has devoted considerable space to discussing the roasting of iron-ores, and illustrated various appliances for facilitating their calcination, particularly with a view to eliminating or reducing the sulphur which they contain.* Attention has also been directed to the fact that there is little reliable data to guide the furnace-man in his experiments, and that most of the roasting has been done without the thorough investigation which the subject is entitled to.

The latest addition to the literature on desulphurization is the record of a series of extended and careful laboratory experiments made by Mr. S. G. Valentine, Ph.D., chemist at the Colebrooke Furnaces, Lebanon, Penna., and presented in a paper entitled "Desulphurization of Pyritiferous Iron-Ores," which appears in the *Transactions of the American Institute of Mining Engineers*, Vol. XVI.

Mr. Valentine had the advantage of an extended experience in using the sulphurous magnetites from the Cornwall Ore-Bank, Lebanon County, Penna., which were roasted with solid fuel in Gjers kilns, and we consider his monograph of such value to those who use sulphurous iron-ores that we give his paper with but slight abridgment.

The results which he obtains and the conclusions which he draws will undoubtedly assist some who have to contend with the problem of using magnetic or other iron-ores which carry considerable sulphur. When we recall the fact that probably 1,600,000 tons of such ores are consumed in the United States annually, the value of these experiments will be appreciated. We hope soon to be able to give some practical results obtained in desulphurizing iron-ore by magnetic separators.

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* *Vide* JOURNAL, Vol. I., No. 3, page 43; Vol. II., page 159 and 208; Vol. III., page 258; Vol. V., pages 17, 41, 87, 171 and 314.

Mr. Valentine's laboratory experiments were made in order to furnish additional information as to the proper conditions for the elimination of sulphur from ores where it is present as sulphide of iron (pyrites), FeS_2.

In the first series of these experiments, pure, roughly-pulverized pyrites crystals were used, containing 53.42 per cent. of sulphur to determine the effect on pyrites, of heat *alone*, in various degrees of intensity and duration, air being altogether excluded. The results appear in the following table:

Approximate Temperature in Deg. Fahr.	Duration of Heat.	Sulphur in Residue. Per cent.	Loss.	Per cent. of Total Sulphur Expelled.
Original Pyrites............	....	53.425	....	....
1250	45 min.	45.500	7.925	14.830
"	5 hrs.	42.591	10 834	20.270
1400	1 "	45.140	8.285	17.379
"	1 "	43.570	9.855	18.446
"	6 "	41.850	11.575	21.665
1600	30 min.	37.933	15.472	28.990
1800	1 hr.	39.389	14.036	26.272
2600	30 min.	29.519	23.906	44.720
"	45 "	31.519	21.906	41 003
"	1¼ hrs.	29.960	23 464	43.917

The residues from these heats had lost their metallic lustre and were generally grayish in color, soft and friable. The samples heated at a white heat were, of course, completely fused. The figures show that, except in the case of a high heat, comparatively a small part of the sulphur was expelled by heat alone without access of air. Contrary to the idea generally prevalent, it is shown by these results that, while a part of the sulphur volatilizes readily, it is by no means easy to get rid of half of it if air is excluded.

The next experiments were undertaken to ascertain the effect of heat on FeS_2 (pyrites) when air is given access freely. These were as follows:

Approximate Temperature in Deg. Fahr.	Duration of Heat.	Sulphur in Residue. Per cent.	Loss.	Per cent. of Total Sulphur Expelled.
Original Pyrites	....	53.425	....	....
1250	1 hr.	4.271	49.154	92.050
"	2¾ hrs.	.700	52.725	98.680
1600	20 min.	.78	52.645	98.540
"	45 "	.08	53.345	99.850
1800	20 min.	.133	53.292	99.751
"	1 hr.	645	52.980	98.790
2200	15 min.	3.231	50.194	93.952
"	20 "	5.916	47.509	88.926
"	35 "	1.558	51 867	97.102
"	2 hrs.	1.181	52.244	97.780

It will be noted that a larger amount of sulphur remains in the residues when higher temperatures have been applied. Mr. Valentine accounts for this by the fact that, the high temperature being quickly reached, a sudden fusion of some of the small particles of pyrites enclosed a portion of the sulphur in such a way as to prevent the action of air upon it.

He claims that "a high temperature is, therefore, not needed for the practically complete decomposition of FeS_2 when air has abundant access. Even at a temperature as low as 1250° F., 98.68 per cent. of the sulphur present was expelled when air had free access. At slightly higher heat 99.85 per cent. was driven off. These results do not bear out the very prevalent idea that, after having got rid of half the sulphur of pyrites, a much higher temperature is required to expel the remainder.

Ledebur, in his *Metallurgy*, says:* "Pyrite and marcasite are decomposed even at a low temperature, while about half the sulphur is volatilized (if air is present, burning to SO_2; if not, passing off as vaporized sulphur) and a compound remains whose constitution corresponds nearly to pyrrhotite (Fe_8S_9). By simple heating, without air, this lower sulphide of iron cannot be further decomposed. If, however, atmospheric oxygen has access to the glowing compound of sulphur and iron, a further part of the sulphur burns, volatilizing as SO_2; the remainder forms next, with the iron, sulphate of iron, which is decomposed, even at a red heat. A part of the oxygen of the SO_2 is used for the higher oxidation of the iron, basic sulphates of iron oxide are formed, and SO_2 vaporized ; on still further raising the temperature, the basic iron salt is also decomposed, SO_2 driven off, and oxide of iron remains behind."

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* *Handbuch der Eisenhüttenkunde*, page 187.

In general, the above-described experiments agree with this statement of Ledebur. But it must be remembered, that in saying that "half the sulphur is volatilized" at a low heat, he evidently means the one atom of sulphur in FeS_2. This, however, only reduces the sulphur from 53.33 per cent. in FeS_2 to 39.66 per cent. in Fe_8S_9. My tests have shown that this is the actual result, although with a white heat, without air, I have succeeded in reducing the sulphur to a somewhat lower point.

From the two tables given it appears that, for proper desulphurization of pyrites air is absolutely necessary, and of greater importance than an excessively high temperature.

Experiments made by Dr. F. Menges, of Pennsylvania College, Gettysburg, Pa., as to the amount of air needed for proper desulphurization of FeS_2, show that with ample air-current all sulphur volatilized will readily burn to SO_2, and that in a deficient air-current any sulphur condensed will be subsequently removed.

In view of the fact that many furnace-men are under the impression that pyritiferous ores can be largely desulphurized in the upper part of the blast-furnace, the following experiments were made: Samples of pyrite were heated in a current of gas taken from the "down-take" flue of a furnace. The gas had the following composition by weight, and gave results as below :

	Per cent.
Carbonic oxide,	31.17
Carbonic acid,	10.06
Nitrogen,	58.72

Approximate Temperature in Deg. Fahr.	Duration of Heat.	Per Cent. Sulphur in Residue.	Loss.	Per Cent. of Total Sulphur Expelled.
Original Pyrites		53.42		
1250	10 min.	41.14	12.22	22.98
"	1 hr.	33.93	19.48	36.68
1800	25 min.	33.88	19.54	36.58

These figures show that the desulphurization of pyrites in an atmosphere of furnace-gas is, at best, only partial, the results being comparable to those obtained when it is heated without access of air. In view of the already ascertained necessity for oxidizing atmospheric surroundings, it could but be expected that in an atmosphere devoid of free oxygen only partial desulphurization could be effected. The furnace-man who hopes to use the top part of his furnace as an ore-roaster has little success to look for.

When sulphate of iron occurs or is formed in the processes of roasting, the question arises as to its behavior on heating: whether or not the presence or absence of air has any influence. It was, of course, known that sulphate of iron decomposes on heating to ferric oxide and sulphur trioxide,* but having seen no statement as to the effect of the presence or absence of air, I made the following experiments:

Two heats, in presence of air for twenty and thirty minutes respectively, at about 1600° F., gave residues showing 0.031 and 0.030 per cent. of sulphur; 99.87 per cent. of the original sulphur having been expelled.

Three heats, with the air excluded, at somewhat higher temperatures than the above, for thirty, thirty-five and sixty minutes, gave residues showing, respectively, 0.04, 0.04, 0.002 per cent. of sulphur; 99.81 to 99.9 per cent. having been expelled.

Sulphate of iron is decomposed by heat alone, the presence of air or its absence having no influence. From this it may be inferred that sulphate of iron is harmless in the blast-furnace, its sulphur being expelled by heat in the form of SO_3 and passing out with the furnace gases. The harmlessness of sulphate of iron is, indeed, known to most furnace-men, although all are not familiar with the reasons for it.

In view of this behavior of sulphate of iron, we inquire next, how far the manner of heating pyrites affects its presence in the residue. Does the presence or absence of air affect the percentage of sulphur in the residue present in the form of sulphate, which we have found to be harmless? To throw light on this point, residues from some of the heats were analyzed to find how far the sulphur contents was in the form of sulphate of iron.

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* Roscoe & Schorlemmer, Vol. II., Part 2, page 101.

1. PYRITES HEATED WITHOUT ACCESS OF AIR.

Temp. ° F. Approx.	Duration of Heat.	Total Sulphur in Residue.	Sulphur as Sulphide.	Sulphur as Sulphate.	Per Cent. of Total Remaining Sulphur as Sulphate.
1250	5 hrs.	42.591	42.399	0.192	0.45
1800	1 hr.	39.389	39.247	0.142	0.39
2600	30 min.	29.519	29.485	0.034	0.10

2. PYRITES HEATED IN PRESENCE OF AIR.

Temp. ° F. Approx.	Duration of Heat.	Per Cent. Total Sulphur in Residue.	Sulphur as Sulphide.	Sulphur as Sulphate.	Per Cent. of Total Remaining Sulphur as Sulphate.
1250	2¾ hrs.	0.70	0.231	.469	67.00
1800	1 hr.	0.645	0.158	.487	75.50
2200	2 hrs.	1.181	0.687	.494	41.83

There is a very marked difference in the results, which show, as might be expected, that free access of atmospheric oxygen must be a condition for the conversion of sulphide into sulphate. Without access of air, practically all the sulphur remaining is in the form of sulphide, but, when air has access, a large part, sometimes the larger part, is in the form of sulphate, a fact which, in view of the harmlessness of the latter in the blast-furnaces, emphasizes the necessity for abundant air in the roasting of pyritiferous ores. Not only is the sulphur removed in this case, but, even of what remains, the greater part is harmless.

Analyses of the residues from those heats made in a current of furnace-gas, given above, showed as follows:

Temp. ° F.	Duration.	Per cent. Totals Sulphur in Residue.	Sulphur as Sulphide.	Sulphur as Sulphate.	Per cent. Total Sulphur as Sulphate.
1250	10 min.	41.148	41.089	0.059	0.143
1250	1 hour.	33.882	33.800	0.082	0.212
1800	25 min.	33.936	33.806	0.130	0.382

These results show that this manner of decomposing pyrites is not conducive to the formation of sulphate in the residue, and that the results here, also, are comparable to those got by heating without access of air.

All the above experiments were made on sulphide of iron alone, which can be expected to act in the same way under the same circumstances under the action of heat. Whether or not an ore containing it will permit desulphurization on the basis of the above-ascertained behavior of FeS_2 depends entirely on the character of the ore itself. If its structure is sufficiently porous to allow air to gain a ready access to the interior of the ore-pieces, it can be expected to desulphurize at a low heat. If it is a close, dense ore this characteristic is equivalent to exclusion of air from the greater part of its sulphur contents. Dense ores are difficult to desulphurize, not because they cannot be heated properly, but because air cannot penetrate them. Therefore, because pyrites can be decomposed at a low heat in presence of abundant air, it does not follow that all ores can be desulphurized under corresponding conditions. While it may be said that atmospheric oxygen is a *sine qua non* for proper roasting, no general rule can be laid down concerning the proper temperature to be used.

To test the correctness of these views the following experiments were made: Small pieces of Cornwall, Pennsylvania, ore, about the size of a walnut, containing, as nearly as could be judged, the same amounts of sulphur, were heated at low temperature under free access of air. The original raw ore showed 2.664 per cent. of sulphur.

Temp. °F.	Duration.	Per cent. Sulphur in Residue.	Loss.	Per cent. Total Sulphur Expelled.
1200	2 hrs.	.346	2.318	87.01
1200	4 "	.178	2.486	93.31
1500	1 hr.	.099	2.565	96.28

From these results it would seem that an open-grained and porous ore can be readily desulphurized at a comparatively low temperature when air has access freely.

The necessity of an oxidizing roasting so that the sulphur remaining shall, as far as possible, consist of sulphate, is proved by an analysis of the same ore:

Temp. ° F.	Duration.	Per Cent. Total Sulphur in Residue.	Sulphur as Sulphide.	Sulphur as Sulphate.	Per Cent. Total Sulphur as Sulphate.
1200	2 hrs.	.346	.235	.111	32.18
1200	4 "	.178	.088	.090	51.12
1500	1 hr.	.099	.027	.072	72.72

Experiments with a very dense New Jersey magnetite show that the density of this ore so completely excluded air from the interior of the ore-pieces, as to make futile any attempt to desulphurize it at a low temperature. It required the use of a high heat.

The action of the heat itself on the ore may either cause a cracking of the ore-piece and allow the entrance of air in that way, or it may act, as pointed out by Akerman, in enabling the sulphur to take up oxygen from the ore itself, for its oxidation. It is certain that the degree of heat required for desulphurization varies with different ores; but an abundant supply of air should always be present.

It is certainly possible, however, to use too high a heat. A fused ore is harder to reduce in the furnace, and heating it to that point appears to be often exceedingly prejudicial to proper roasting.

To test this point (how far fusion or clinkering of ore affects the amount of sulphur that can be expelled, and how far its influence goes to affect the amount of the sulphur remaining in the clinker present in the form of sulphate) small pieces of Cornwall ore, similar to those used before, were heated beyond their sintering point, as quickly as possible, to intensify the effect. For comparison the former results, obtained on heating at a low temperature, are added:

No. of Heat.	Temp. ° F.	Duration.	Per Cent. Total Sulphur in Residue.	Sulphur as Sulphide.	Sulphur as Sulphate.	Per Cent. Total Sulphur as Sulphate.
1	1200	2 hrs.	0.346	0.235	0.111	32.18
2	1200	4 "	0.178	0.088	0.090	51.12
3	1500	1 hr.	0.099	0.027	0.072	72.72
4	2400	45 min.	2.125	....	....	....
5	2400	" "	2.422	2.337	0.085	3.50

Recalling the fact that the raw ore contained 2.664 per cent. of sulphur, the effect of the sudden fusion can be readily noted in the differences between the results of the first three heats and of the last two.

The following are analyses of some clinkers taken from roasters working on Cornwall ore, showing the same effect:

Per Cent. Total Sulphur.	Sulphur as Sulphide.	Sulphur as Sulphate.	Per Cent. Total Sulphur as Sulphate.
1.397	1.224	.173	12.380
1.380	1.245	.135	9.782
1.873	1.777	.096	5.125

These indicate plainly that the fusion of ores in roasting may prove prejudicial to good results. The viscid coating of fused iron oxide, silica, and lime, or whatever may, in various cases, go to make up the impervious exterior, is a barrier both to ingress of air and egress of sulphur in any form. If the heat in any roasting process must be carried to so high a point, it should be gradually raised, and sintering should take place only after continued heating at a lower temperature in abundant air. I have frequently found pure sulphur condensed in the cavities of cold clinkers, where it had been vaporized from pyrites, but was unable to escape. Clinkering ore quickly is equivalent to roasting without air, and even more, for the sulphur that heat alone would vaporize is imprisoned in the mass. Furthermore, it prevents any great amount of the sulphur left from being in the form of sulphate.

Ledebur states that desulphurization will be the more complete the smaller the pieces of ore, the more freely air has access, and the higher the temperature on roasting. Small pieces mean greater surface exposure and less requirement for penetration of heat and air. And we have seen that air is absolutely needed for anything like a complete desulphurization. But our results do not bear out the asserted necessity of a high heat for thorough roasting in all cases.

The practical application of all these conditions in the roasting of ores is a matter of no little difficulty. A proper roaster must be one in which the heat is under control, the ingress of air ample, and the egress of the products of combustion prompt. A gas-roaster seems to approach most nearly to these conditions. The Gjers kiln in any of its forms seems to be a deficient apparatus for desulphurization, because it has none of these qualifications. Its effectiveness is about on a par with roasting without air, for little or no air can get at the ore while it is being heated in this style of kiln. Being fired with solid fuel, it is, as a rule, under little control as to temperature, and the great number of them are chronically "clinkered."

The workings at the the Musconetcong Iron Works, New Jersey, of a modified form of this kiln, as given by Mr. I. P. Pardee, were as follows:

	Per cent. Sulphur.
Raw ore,	0.883
"	0.68
Roasted ore,	0.39
"	0.29

Cornwall ore roasted in Gjers kilns gives the following results:

	I.	II.	III.	IV.
Per cent. sulphur,	.80	1.41	1.05	1.12

As this ore contains from 2½ to 3 per cent. of sulphur, the analyses show only imperfect desulphurization, and are comparable to roasting out of contact with air. As a rule, not more than half the sulphur is removed.

The following conclusions may be drawn from this investigation, in regard to pyritic ores:

1. Heat alone, without access of air, can remove, at best, only one-half of the sulphur present.

2. Atmospheric oxygen is absolutely necessary for a proper desulphurization.

3. Even at a low heat, ore is properly desulphurized if air can gain access freely to the FeS_2 in it.

4. Sulphate of iron can be decomposed by heat equally well with or without air.

5. In order that the residuum of sulphur in roasted ores may consist, so far as possible, of sulphates, the roasting must be done under free access of air.

6. Fusion or sintering of ore is likely to prevent any further desulphurization.

7. Sintering does not allow much of the remaining sulphur to be in the form of sulphate.

8. Fusion, hence, should never occur in roasting except after continued heating in air at a lower temperature.

9. Ores cannot be properly desulphurized in the upper part of the blast-furnace.

10. An efficient roaster must allow easy control of heat, abundant air access to the hot ore, and rapid removal of the products of combustion.

Lake Champlain Iron Region.

NOTWITHSTANDING that iron-ore was mined and iron produced in northern New York in 1804, and, possibly, prior to 1800, and that the section of the State recognized either as the Adirondack or the Lake Champlain region (because it embraces portions of the Adirondack Mountains and the western shore of Lake Champlain) has continued to exert an important influence in the iron industry, the true position of this interesting district is seldom appreciated.

The legends of the Indian battles, and the stories of the conflicts between the French, British, and Americans, have made Fort Ticonderoga, Crown Point, and Plattsburgh historical, while summer outings have brought into prominence the lakes and peaks of the Adirondack Mountains.

To those interested in iron-ore mining and iron manufacture, there is much which divides interest with the historic and scenic attractions of this section, and we shall endeavor to give in the JOURNAL such facts as we believe will be acceptable to our readers. We shall incorporate in this sketch some data which has appeared in previous issues of the JOURNAL, but only such as is believed essential for a proper presentation and a thorough appreciation of the importance of the district under consideration. We shall not, at this time, attempt a historical sketch, contenting ourselves for the present with some extracts of interest, and discussing one of the important mining districts.

HISTORICAL.

Mr. William G. Neilson prepared, in 1867, for the American Iron and Steel Association, a monograph on the blast-furnaces, rolling-mills, forges, and steel-works of New York. He mentions two active and three abandoned charcoal furnaces in the Lake Champlain district. Of two of the latter he says: "Dannemora Furnace was situated in the State Prison yard at Dannemora, Clinton County. It was built in 1854, burnt and abandoned July 19, 1856. It worked magnetite-ore from a mine within the enclosure, convict labor being employed. . . . . The Adirondack Iron Works, 48 miles west of Crown Point Landing, Essex County, N. Y., embraces a property of over 100,000 acres in one tract, and comprising some of the most extensive deposits of magnetic-ore in the country. It was purchased about 1830 by the Adirondack Iron and Steel Company, and is still owned by the heirs of the original parties. . . . . The mineral value of this tract is treated of by Prof. Emmons in his report on the geology of this part of New York. (*Nat. Hist. Series.*) The ore is of great richness and purity. Blooms were made here direct from the ore about 1838 or 1840. A charcoal blast-furnace was erected about 1848, and is still standing, but is in ruin. It made iron up to about 1853. At first it was very small, but it was subsequently enlarged, until it was probably 42 feet high and 7 feet across the boshes. The ore is refractory, and requires a high temperature and a high furnace. The Company also put up a puddling-furnace and a cupola-furnace. In 1848 they built the Adirondack Steel Works in Jersey City. A new blast-furnace was built on the property and finished about 1854. It is 36 feet square and 48 feet high, and 11½ feet across the boshes, and cost $43,000. It made two blasts of about six months each, probably in the years 1855 and 1856; about 1200 tons were made at each blast. It has been idle since. There is a puddling-furnace and two centre lift-hammers at the works. The iron was shipped as hammered bar-iron, and used at Jersey City. Some was shipped as pigs. The furnace and works are still in good condition, and were not permitted to be destroyed. The cause of the abandonment of the manufacture of iron at this place was the difficulty of transportation. It had to be hauled in wagons 48 miles to Lake Champlain."

Since the above was written (1867), this deposit, upon which a large amount of money was expended, has lain dormant, and the buildings located upon it have largely become wrecks by the action of the elements. Several efforts to revive operations have proven unsuccessful on account of the property being still remote from modern transportation facilities, and because of the high percentage of titanium which the ore contains. About a year ago Mr. W. H. Scranton, lately deceased, made a thorough and comprehensive magnetic survey of the property, and informed the writer of the apparent immensity of the deposit.

None of the furnaces mentioned by Mr. Neilson are now active, but two others, the Plattsburgh and Standish, have been built, and are now on the active list. They are operated by the Chateaugay Ore and Iron Company. He also described 30 forges, with 136 fires and 41 hammers active in 1866, and 9 abandoned forges; also 3 active and 2 abandoned rolling-mills in the Lake Champlain district. All of these works were operated with charcoal, and some of the forges are still employed in the production of blooms by the American bloomery or modified Catalan process. The statistics of the American Iron and Steel Association give the following data concerning the number of bloomaries and forge fires of northern New York, and their annual product:

STATISTICS OF FORGES IN NORTHERN NEW YORK.

Year.	Number of		Total make. Net tons.
	Forges.	Fires.	
1880	23	174	34,351
1881	....	....	39,892
1882	27	190	43,911
1883	....	....	31,347
1884	28	174	27,745
1885	....	....	18,981
1886	....	....	15,507
1887	....	....	15,043
1888	22	148	14,050

A full description of these forges, their construction and operation, is found in the JOURNAL, Vol. II., page 100 to 123, and we need only summarize.

The dense magnetites obtained in the Adirondack region were roasted in open stalls to facilitate reduction under gangue stamps. The product of these stamps was jigged on trays, and later by revolving jigs to remove the gangue, the concentrate being fed into charcoal fires supplied with hot blast. The resulting loupe was hammered into a large bloom, which was returned to the fire and cut into smaller blooms. These are now used to manufacture horseshoe nails, and enter largely into the manufacture of high-grade steel plate in open-hearth furnaces.

Although the Adirondack region is still an important centre of charcoal iron production, the extent and diversity of this industry is much restricted, and the district now is better known on account of the supply of excellent magnetic iron-ores which are obtained and shipped to prominent iron and steel works.

In addition to the two active charcoal blast-furnaces above mentioned, there are five anthracite furnaces on the west shore of Lake Champlain; two of these are at Crown Point, and three at Port Henry. The machinery equipments of several of these furnaces rank among the largest and most expensive in the country; and the introduction of fire-brick stoves in connection with American blast-furnace practice was first made in the Lake Champlain district, the Cedar Point furnace at Port Henry erecting the first Whitwell stoves, and the Crown Point furnace the first Cowper stoves.

IRON-ORES.

The most important iron-ore region in New York State is "the Lake Champlain district," embracing three general groups of mines located as follows:

1. At Hammondville, 13 miles west from, and 1300 feet above, Lake Champlain, at Crown Point, where the veins have an apparent strike of 2 miles in length.

2. At Mineville, 7 miles west from, and 1200 feet above, Lake Champlain, at Port Henry, where the veins have an apparent strike of over 3 miles in length. The Port Henry mines are 12 miles north of the Crown Point mines. Both of these deposits may be considered as in the foot-hills of the Adirondack Mountains.

3. At Lyon Mountain, 30 miles west from, and 1900 feet above, Lake Champlain, at Plattsburgh, where the apparent strike of the veins is 9 miles in length. This deposit is known as the Chateaugay mines. It is in the Adirondack Mountains, 60 miles north of the Port Henry mines, and is not considered as being identical in formation with the other mines.

Other deposits between those named, or closer to the lake, have also been exploited and operated; many small mines having formerly been worked for forges and since been abandoned. The three groups of mines mentioned are supplied with branch railroads which connect with the trunk railroads and with shipping docks on Lake Champlain, at Crown Point, Port Henry and Plattsburgh.

The total output of this district to date is estimated at about 15,000,000 gross tons, of which nearly 6,000,000 tons were mined in the last ten years. From the mines at Mineville over 9,000,000 gross tons are estimated to have been taken.

The total production of this region in 1888 as set forth in a previous number of the JOURNAL *vide* Vol. VIII., page 198, is as follows:

	Gross tons.
From mines near Port Henry, N. Y.,	419,009
" " of Chateaugay Ore and Iron Company,	250,500
" " near Crown Point,	74,910
" other mines, estimated,	45,000
Total,	789,419

THE PORT HENRY MINES.

The group of iron-ore mines in the town of Moriah, Essex County, N. Y., embraces the largest producers in the Lake Champlain district. These are operated by the Port Henry Iron-Ore Company, and Messrs. Witherbees, Sherman & Co., who own all the developed ore-bodies in the vicinity of Mineville, and jointly own and operate the railroad which connects Mineville with Port Henry. The latter is the shipping port on Lake Champlain to which all the ore mined is carried by cars over a road of standard gauge having three switchbacks on it, as the difference of elevation to be overcome in 6 miles is 1200 feet. The maximum grade is 1 in 24 (220 feet per mile), but as the loaded cars are carried from the mines to the lake the objection to heavy grades is less than if the conditions were reversed. The properties of the two companies are contiguous, and to a stranger the locality of some of the workings appear very confusing owing to being close together. These openings are generally known to the iron trade as the Port Henry mines. Locally they are recognized as Moriah mines, or Mineville openings, and we will first present data concerning this group:

The Port Henry mines produce two distinct varieties of ore, one being a magnetite carrying apatite in such quantities as to raise the phosphorus beyond the Bessemer limit, known as "Old Bed 21" ore and the other being a magnetite carrying a siliceous gangue, but very low in phosphorus, known as "New Bed" ore. These general designations apply to ores obtained from various openings, the first portion of the commercial name "Old Bed" being derived from the original opening made in 1824, and now owned by Witherbees, Sherman & Co., from which a large amount of ore has been won in workings extending 1100 or 1200 feet on the slope to a vertical depth of 300 feet. The No. 21 opening of the Port Henry Iron-Ore Company, which supplies the second portion of the commercial name for the ore, with its several shafts 200 feet south of the "Old Bed" opening, which was started in 1829, is however, the largest producer, and one of the most impressive mines to view in the world. The massive pillars of ore supporting the roof (also of ore), capped with rock to within 50 feet of the surface are exposed in the great open pit to a height of 200 feet, while the chambering extends much beyond the face and to a depth of about 350 feet vertically from the surface, the distance along the slope being 700 feet.

Northwest of the Old Bed opening is the Miller pit of Witherbees, Sherman & Co. This is on nearly the same level as the Old Bed and No. 21 ore-bodies, and although the slope is approximately the same, the ore strikes at different elevations, but in nearly parallel directions, in each of the three veins, and a fourth ore-body apparently lies between the Old Bed and the Miller pit seams. An opening of the Port Henry Iron-Ore Company, appears to be a continuation of the original Old Bed pit, while two openings of Messrs. Witherbees, Sherman & Co. seem to be on the same ore-body as No. 21.

All of the above openings produce what is known commercially as "Old Bed 21" ore, but the percentages of phosphorus vary in the different workings, none, however, being Bessemer ore. The deepest workings are now 500 feet vertically below the surface. The average shipping analyses of the ore vary from 62 to 68 per cent. of iron, and from 0.5 to 2 per cent. of phosphorus.

One and a half miles northeast of the openings described are two shafts producing similar ore. These are a slope about 1200 feet and a vertical shaft about 800 feet deep, reaching a large body of ore. Neither of these are worked at present, as the railroad tracks do not reach them. Other exploitations have been made in the vicinity of the mines above described, and ore from various openings was taken to blast-furnaces or forges which existed in the vicinity.

The openings producing "New Bed Ore" cover a greater territorial area on account of being made upon a vein which is apparently continuous but divided into two or three layers, while the various deposits of "Old Bed Ore" seem to be a series of lenses lying in eschelon or in nearly parallel veins of varying thickness and dip.

The layers of the New Bed vein average about 8 feet in thickness, increasing at some places to 20 feet, while the maximum thickness of the Old Bed ore-bodies is yet undertermined; thus the Miller pit ranges from 10 to 100 feet, the Old Bed pit from 20 to 125 feet, while in No. 21 the pillars rest on ore and support a roof of ore, the body being known to exceed 380 feet in thickness. The newer shafts of Witherbees, Sherman & Co., the Bonanza and Joker, vary from 30 to 150 feet in thickness. The pitch of both New and Old Bed veins average about 30 degrees from a horizontal line, but varies greatly, sloping to nearly vertical or flattening considerably, and sometimes returning in a roll.

The original New Bed opening has been continued along the strike for 2000 feet, reaching a vertical depth of 500 below the surface, and from the end of the present workings to the furthest exploitation of the vein is about 2½ miles. In this distance there are a number of workings all operated by Witherbees, Sherman & Co., except the Fisher Hill opening, which is worked by the Port Henry Iron-Ore Company, which has up to the present followed the dip for 1000 feet. There is therefore no apparent prospect of exhaustion of either the Old Bed 21 or the New Bed ore; and it is doubtful if there is an iron-ore deposit in the United States which produces richer ore than some portions of the New Bed vein.

The average of present shipments of "New Bed Pure" ore, made up from daily analyses, shows iron 66, phosphorus 0.025, and "New Bed Lean" ore carries about 55 per cent. of iron, with phosphorus inside of the Bessemer limit.

Occasional horses of rock cut into the Old Bed lenses, while the

New Bed has a series of faults caused by pyritiferous material, but sulphur is not found in the ore. On the other hand, pockets of ore approaching chemical purity are met with, and in April one of these was opened by a shaft sunk through 18 feet of the floor of a portion of the New Bed vein which was apparently approaching exhaustion. We had the opportunity of inspecting this deposit (locally known as Lover's Hole), and saw the vein of clean crystalline ore exposed for 200 feet, the thickness increasing from 4 feet to 15 feet, with indications of still greater thickness. Viewed with the electric light the multitudinous crystals produced a really dazzling sight which is worth a journey. In the JOURNAL, page 202, we referred to some of the crystals found in the New Bed ore, and from the broken material we picked some handsome specimens.

At the time of our visit, Lover's Hole had produced about 8000 tons of this high-grade ore, the daily samplings of which show that the iron contents range from 69.20 to 72.04 per cent., and the phosphorus from 0.011 to 0.026. We doubt if a similar quantity of ore as high in iron and as low in phosphorus has ever been mined from one opening in this country.

The occurrence of this deposit gives reason to believe that the New Bed ore lies in three layers, separated from each other by rock floors.

Messrs. Witherbees, Sherman & Co. publish the following complete analyses of the shipping ores obtained from the Port Henry mines:

ANALYSES OF PORT HENRY, N. Y., IRON ORES.

	Old Bed 21.	New Bed Pure.	New Bed Lean.
Pure metallic iron,	66.18	68.24	50.38
Oxygen with the iron,	25.23	26.01	19.20
Insoluble siliceous matter,	1.94	4.32	29.11
Phosphoric acid,	2.45	0.04	0.05
Alumina,	0.76	0.28	0.32
Lime,	2.27	0.14	0.17
Magnesia,	0.14	......	......
Water,	......	0.38	0.54
Protoxide of manganese,	0.36	......	......
Undetermined matter and loss,	0.67	0.59	0.23
	100.00	100.00	100.00
Pure metallic iron,	66.18	68.24	50.38
Phosphorus,	1.07	0.018	0.021
Sulphur,	none	......	none

In our articles upon "Iron-Ore Concentration," we have given results obtained by separating these ores by magnetism. Owing to the crystallization of the ore it breaks up readily, especially the "New Bed Pure," and the "Old Bed 21" ore; as a consequence much of the ore becomes fine in handling and shipping. The "New Bed Lean" ore, however, is more difficult to crush, owing to the siliceous gangue in which the ore crystals are disseminated, but very satisfactory concentrations are made from this ore, while the "Old Bed 21" ore when crushed and separated shows a very large reduction of phosphorus.

In connection with the Port Henry mines mention should be made of the Cheever ore-bed, located 2 miles from Port Henry, near the shore of Lake Champlain, for which the Bay State furnaces at Port Henry hold the right for ore at 50 cents a ton above the cost of mining. The strike of this vein is peculiar, in that it first descended and then rose close to the surface in bow form. This vein varied from 8 to 15 feet in thickness and is practically worked out, present exploitations being in an outlying deposit from which 25 to 30 tons are obtained daily, the composition being:

	Per cent.
Metallic iron,	56 to 62
Phosphorus,	0.2 to 0.6

In Watson's *History of Essex County*, the statement is made that the Cheever ore-bed was utilized as early as 1804, and mention is made of three other ore-beds near by. The following analyses by Prof. Hayes, dated 1856, are given:

OLD ANALYSES OF CHEEVER ORE, PORT HENRY, N. Y.

Proto- and peroxide of iron,	90.54
Phosphate of lime,	3.80
Amphibole,*	2.80
Silicic acid,	1.60
Pilaniferous iron,†	1.26
	100.00
Metallic iron,	64.15
Oxygen with it,	24.45
Silex,	4.10
Lime and magnesia,	1.10
Phosphate of lime,	6.20

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* Hornblende.

† Pilaniferous intended possibly for titaniferous.

While neither analysis meets the requirements of present practice, they are inserted as of interest to our readers.

Watson says of the mines near Moriah, here referred to as the Mineville deposit, that the first openings were made in 1824, and gives the following analyses:

OLD ANALYSES OF MINEVILLE ORES.

	Old Sanford Bed.	Old Bed 21.	New Bed.
Metallic iron,	72.09	......	71.19
Protoxide of iron,	......	25.29	......
Peroxide of iron,	......	71.65	......
Silica and insoluble siliceous matter,	0.34	2.22	1.12
Phosphorus,	0.01	......	trace
Phosphate of lime,	......	0.39	......
Oxygen and moisture,	27.56	......	27.69
Alumina,	......	0.40	......
Oxide of titanium,	......	trace	......
Magnesia,	......	0.05	......
	100.00	100.00	100.00
Metallic iron,	72.09	69.82	71.19

He gives the product of the several ore-beds in the town in 1868, as follows:

	Tons.
Cheever bed,	68,000
Mines of Port Henry Iron Ore Company,	59,000
Mines of Witherbees, Sherman & Co,	59,500
Mines of Lake Champlain Mining Company,	2,500
Mines of M. T Smith,	14,500
Mines of Fisher bed,	6,500
Total,	210,000

There are several mine openings near Port Henry which are not now worked.

The machinery equipments at the mines tributary to Port Henry are elaborate, the system being to use a central power-house from which wire ropes are carried to the various shafts and openings by sheaves supported on iron columns. The Port Henry Iron Ore Company are now erecting a new hoisting plant at the No. 21 pit, and Witherbees, Sherman & Co. are constructing a telpherage system to handle some of the New Bed ores. The mines are unusually dry, the roof is generally good, and mining can therefore be carried on to advantage.

In a future issue we will describe other mines in the Lake Champlain and Adirondack region.

German Mineral Statistics.

THE official statistics in regard to the mineral production and metal manufacture of Germany in the year 1888 were as follows:

	Total production.		Average value per metric ton of 2204 lbs.	
	1888.	1887.	1888.	1887.
	Tons.	Tons.	Marks.*	Marks.*
Coal	65,321,834	60,333,984	5.22	5.16
Brown coal	16,541,977	15,883,634	2.46	2.53
Salt	414,557	405,420	4.38	4.59
Iron-ore	10,664,789	9,351,106	3.75	3.64
Zinc-ore	667,760	900,712	20.59	11.13
Lead-ore	161,775	157,570	102.83	101.06
Copper-ore	530,864	507,587	32.99	28.67
Salt	493,400	480,962	21.58	23.75
Pig-iron, total	4,258,471	3,954,413	43.90	41.12
For foundry	597,488	488,573	46.59	45.98
For soft steel	1,794,806	1,732,484	43.90	41.23
For Bessemer steel	1,825,792	1,692,674	41.93	38.40
Zinc (metal)	133,224	130,493	327.09	280.45
Lead (metal)	96,995	94,920	256.18	236.99
Copper (metal)	20,872	20,202	1146.11	877.24

The production increased in 1888, with the exception of zinc-ore.

Mr. R. Schroedter in a paper on "The Progress Made in the German Iron Industry Since the Year 1880," read before the British Iron and Steel Institute, gives the following table showing the amount of iron-ore produced in the German Empire in the last nine years.

IRON-ORE MINED IN GERMANY.

Years.	Metric Tons.			Value.	
	In Germany.	In Luxemburg.	Total.	Pounds.†	Dollars.
1880	5,065,176	2,173,664	7,238,840	1,722,664	8,423,826.96
1881	5,436,919	2,161,882	7,598,801	1,804,276	8,823,909.64
1882	5,786,449	2,476,805	8,263.254	1,959,083	9,579,915.87
1883	6,180,641	2,575,976	8,756,617	1,965,935	9,613,422.15
1884	6,554,342	2,451,454	9,005,796	1,877,155	9,179,287.95
1885	6,509,379	2,648,490	9,157,869	1,695,671	8,291,831.19
1886	6,051,579	2,434,179	8,485,758	1,482,170	7,247,811.30
1887	6,701,395	2,649,711	9,351,106	1,700,263	8,314,286.07
1888	....	....	10,664,789	1,998,200	9,771,198.00

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* A mark is equivalent to 24 cents U. S. money.

† The pound is taken at $4.89.

"In 1880 there were 314 furnaces, 246 of which were in blast, and in 1887, 271 furnaces, of which 212 were in blast.

"In the great producing areas, Rhineland, Westphalia, Lorraine and Luxemburg, the mean capacity of a blast-furnace in each twenty-four hours is 80 to 120 tons, according to the grade of iron produced and the nature of the ore smelted. The consumption of coke for these furnaces may be taken as 0.9 to 1.0 ton per ton of pig-iron. In Upper Silesia, on the other hand, the consumption of coke in 1887 averaged 1.650 ton per ton of pig-iron. All the larger blast-furnaces have fire-brick hot-blast stoves, the preference being almost universally given to the Cowper system of applying the Siemens regenerative principle. The Ilsede blast-furnaces are unequalled in their efficiency.* The consumption of coke at those works for making basic pig-iron with 2.9 per cent. of phosphorus, 2.38 per cent. of manganese, and 0.1 per cent. of silicon, is 0.851 ton per ton of pig-iron. The total out-turn of the three furnaces during 1888 amounted to 116,098 tons. The daily production of No. 3 blast-furnace was 158 tons; the workmen's wages amounted to 2s. 6d. (60 cents) per ton; and the total cost of production was not more than 23s. ($5.52) per ton. The number of puddling furnaces is roughly 2200, of which 60 to 85 per cent. are in regular operation. The production of basic pig-iron in 1888 is stated to have amounted to 1,253,308 tons."

* * *

THE *London Iron and Steel Trade Journal* states that five of the largest iron companies in England, with a capital of £10,555,000 ($51,615,000), have realized nothing on one-half of their investments during the last six years. On £3,650,000 ($17,849,000) the highest dividend paid was only 3 per cent. for two years out of five, and on £2,193,000 ($10,726,000), during the last six years, the dividends ranged from 2 per cent. to 1⅜ per cent. in three of the years, and from ¼ to 1 per cent. paid out of the reserve for the last three years.

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* In the JOURNAL, Vol. VIII., page 64–5, we gave the items of cost entering into the manufacture of pig-iron at the Ilsede furnaces, and on page 200, Vol. VIII., analyses of the ores used were presented.

Mineral Products of the United States.

THE sixth report on "The Mineral Resources of the United States," by David T. Day, Chief of the Division of Mining Statistics and Technology, United States Geological Survey, for the calendar year 1888, contains detailed statistics for this period, and also for preceding years.

METALS.

The principal statistics for iron and steel for 1888 were: Domestic iron-ore consumed, about 12,060,000 long tons; value at mines, $28,944,000; an increase over 1887 in quantity of 760,000 tons, but a decrease in value of $4,956,000. Imported iron-ore consumed, 587,470 long tons; total iron-ore consumed in 1888, about 12,650,000 long tons,* or 150,000 tons more than in 1887. Pig-iron made in 1888, 6,489,738 long tons; value at furnace, $107,000,000; an increase over 1887 of 72,590 tons in quantity, but a decrease of $14,925,800 in value. Steel of all kinds produced in 1888, 2,899,440 long tons; value at works, $89,000,000; a decrease from 1887 of 439,631 tons in quantity and of $14,811,000 in value. Total spot-value of all iron and steel made in 1888, in the first stage of manufacture, excluding all duplications, $145,000,000; a decrease of $26,103,000 as compared with 1887. Limestone used as a flux in the manufacture of pig-iron in 1888, about 5,438,000 long tons; value at quarry, about $2,719,000.

According to the director of the mint, the gold product was 1,604,927 fine ounces, valued at $33,175,000. The silver product was 45,783,632 fine ounces, of the commercial value of about $43,000,000. In addition to the product of our own mines, some 10,000,000 ounces of silver were extracted in the United States from foreign ores and bullion.

The total copper product, including the yield of imported ores, increased to 231,270,622 pounds, or 115,635 short tons, during 1888, which is 46,053,291 pounds more than the product of 1887.

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* This agrees very closely with the estimate made in the last issue of the JOURNAL, page 155, of 12,700,000 tons.

The prices received by American producers averaged 15½ cents per pound for Lake copper, 14½ for Arizona, and 14 for other districts; making the total value $33,833,954. Montana led in the production, making 97,897,968 pounds.

The lead product increased to 180,555 short tons from 160,700 tons in 1887, due principally to the heavier receipts of lead in Mexican silver-lead-ores from 15,000 tons in 1887 to over 27,000 tons in 1888. The average price in New York was 4.41 cents per pound. The production of white lead, chiefly from pig-lead, was 89,000 short tons, valued at $10,680,000.

The zinc production in 1888 was 55,903 short tons, with a total value of $5,500,855; in 1887, 50,340 tons, worth $4,782,300. The production of zinc white in 1888, directly from ores, was 20,000 short tons, worth $1,600,000.

33,250 flasks of quicksilver (of 76½ pounds each) were produced in California, which averaged $42.50 per flask, making the total value $1,413,125.

The product of manganese and manganiferous iron-ores in the United States in 1888 was 239,460 tons, valued at $876,215. Of this amount some 25,500 tons would be classed as manganese-ores. Of the manganiferous iron-ores 11,462 tons, averaging 11 per cent. of manganese, and 189,574 tons, averaging 4 per cent. of manganese, were from the Colby iron-mine, Michigan. In addition to the above, some 60,000 tons of argentiferous manganese-ores, valued at $10 a ton, chiefly for the silver contained in them, were produced in the Rocky Mountain region.

The production of metallic aluminum as an industry distinct from the production of alloys began towards the close of the year, and 500 pounds had been made up to December 31st; the production of 3000 pounds since then indicates that the industry may continue. 18,000 pounds of aluminum contained in bronze and ferro-aluminum were produced. The price for metallic aluminum declined to as low as $4.50 per pound for less favored brands.

Including the platinum and iridium separated from gold by the assay offices and that saved in placer gold mining, the product was about 500 ounces, valued at $2000.

Pyrites.—Production 54,331 long tons, valued at the mines at $167,658; a slight increase in quantity over the previous year.

FUELS.

The total production of all kinds of commercial coal in 1888 was 142,037,735 short tons (increase over 1887, 18,022,480 tons), valued at the mines at $204,221,990 (increase, $30,625,994). This may be divided into Pennsylvania anthracite, 43,922,897 short tons (increase, 4,416,642 short tons), or 39,216,872 long tons; all other coals, including bituminous, brown coal, lignite, small lots of anthracite produced in Colorado and Arkansas, and 4000 tons of graphitic coal mined in Rhode Island, amounting in the aggregate to 98,114,838 short tons (increase, 13,605,838 tons); valued at $118,572,341 (increase, $24,341,589).

The production of coke in the United States in 1888 was 8,527,560 tons, valued at about $14,000,000. Pennsylvania produced by far the largest amount, the Connellsville region alone producing 4,955,553 tons; West Virginia, 528,533 tons; Alabama, 518,511 tons; Tennessee, 385,693 tons; and Virginia, 149,099 tons.

The production of petroleum in the United States in 1888 was 27,346,018 barrels (of 42 gallons each), valued at about $24,598,559. Of this amount Pennsylvania produced 16,491,083 barrels; Ohio, 10,010,868 barrels; West Virginia, 119,448 barrels; California, 704,619 barrels, and other States 20,000 barrels.

It is estimated that the amount of coal displaced by natural gas in the United States in 1888 was 14,163,830 tons, valued at $22,662,128. Of this amount 12,543,830 tons were displaced in Pennsylvania; 750,000 tons in Ohio, and 660,000 tons in Indiana.

The total value of the minerals produced in 1888 was $591,659,931. It is recognized that this is the sum of the values of substances taken in various stages of manufacture, and hence not strictly comparable with each other; still it is the most valuable means for comparing the total products of different years. The result is an increase of nearly $50,000,000 beyond the value of the product in 1887.

Résumé of the Values of the Metallic and Non-Metallic Mineral Substances Produced in the United States in 1888.

Metals,	$256,245,403
Mineral substances named in the foregoing table,	328,914,528
	$585,159,931
Estimated value of mineral products unspecified,	6,500,000
Grand total,	$591,659,931

The Iron-Ores of British Columbia.

MR. GEO. M. DAWSON, of the Canadian Geological Survey, in a pamphlet entitled *The Mineral Wealth of British Columbia* gives the following description of her iron-ores:

"Most of the ores of iron so far found in quantity are magnetites, which occur in association with the older metamorphic rocks of the Province. Clay iron-stones are, however, of frequent occurrence in the coal seams of Vancouver and Queen Charlotte Islands, as well as in the Tertiary rocks of the interior. These might, no doubt in some cases, be profitably worked in conjunction with the coal-seams, as they occur in the same strata, and in some instances are even associated with the coal. The nodules vary in weight from a pound or less up to several tons, and at Baynes Sound mine a sufficient quantity might probably be obtained for the regular supply of a blast-furnace.

"The only iron-ore deposits which have yet been worked are those of the Southwest side of Texada Island, the largest exposures of ore occurring about 3 miles northwest of Gillies Bay. Here the ore-mass is seen to be from 20 to 25 feet thick, and constitutes a somewhat irregular contact deposit between limestone or marble and granite, thin veins of the ore being occasionally found reticulating the limestone. From this point to the northward, for nearly a mile, the ore is occasionally seen, and at one place there is a continuous exposure about 250 feet long and from 1 to 10 feet thick. As regards mining and shipment the ore is most favorably situated; while in the event of smelting operations being undertaken on the spot, there is abundance of wood suitable for making charcoal on the island, and Comox Harbor, from which the coal of the Comox area may be shipped, is less than 20 miles distant. The ore is a magnetite of excellent quality. A partial analysis by Dr. B. J. Harrington, in the laboratory of Survey, showed 68.40 per cent. of iron, with only .003 per cent. of phosphorus. A partial analysis by Whitfield, representing a lot of 600 tons, shows iron 65.71, phosphorus .013. [A more detailed analysis will be found in the JOURNAL, Vol. VIII., page 146.—ED.]

At the principal deposits of ore, situated as above described, a wharf has been built, and excellent arrangements made for mining and shipping. The ore is brought to the wharf by an incline nearly a ¼ of a mile in length, from the point at which it is quarried out, about 250 feet above the sea level. Considerable quantities of ore have been shipped from time to time to the works of the Puget Sound Iron Company, situated at Irondale, Washington Territory. The Texada ore is there mixed with from one ninth to three-tenths of bog ores found near Irondale, and produces thus, or when smelted alone, an excellent quality of foundry pig. The shipments in 1885 amounted to 190 tons; in 1886, 3941 tons; in 1887 to 1410 tons; and in 1888 to 7300 tons.

Iron-deposits of the same character in considerable mass are again found on the opposite or northeast shore of Texada Island, and very probably are more or less continuously developed along the contact of the granites and limestones elsewhere in the island.

Magnetic iron-ores of somewhat similar character occur in the hills to the east of Sooke Harbor, Vancouver Island. The deposits are about 20 miles from Victoria, near the coast, and well situated for shipment. The deposit is rather of the nature of a stoke-work than a true vein, but can be traced for some distance in a northeast and southwest direction, and in places shows from 10 to 20 feet of nearly pure ore. The country-rock is a coarsely crystalline diorite (?) containing much hornblende. The following assays of various specimens of the ore gave the percentage of metallic iron:

	Iron.
By William Julian, San Francisco,	72.40
" Thomas Price, " "	51.80
" " " "	57.30
" J. T. Bernige, Cornwall,	48.90
" " " "	68.50
" J. Kestle & Co., San Francisco,	64.50
" D. Wallace, Glasgow,	61.50
" " "	65.00

Magnetic iron-ore occurs in considerable mass in the Queen Charlotte Islands, on the east side of the entrance to Harriet Harbor, Skinkuttle Inlet. No attempt has, however, yet been made to utilize this ore. Occasional strings of pyrites traverse the ore, but it is, as a rule, remarkably pure. Specimens of an average character, collected in 1878, and examined in the laboratory of the Survey, proved to contain 58.06 per cent. of metallic iron, while an exceptionally good fragment yielded 69.88 per cent.

Very fine specimens of magnetite have been brought from an island in the Walker group, in Queen Charlotte Sound, near the north end of Vancouver Island. These proved to contain 71.57 per cent. of metallic iron. Another specimen of a similar ore comes from a deposit, which is reported to be extensive, on the north side of Rivers Inlet, about 25 miles up from its entrance. Numerous other localities of iron-ores will doubtless be found when sought for. Some additional occurrences of magnetites have been noticed at the following places:

Cape Commerell, on the north end of Vancouver Island. Magnetic iron sands are found along the shores, but scarcely in sufficient quantity to be of economic importance.

One mile up the river, at the head of the Knight Inlet, at a point 1200 feet up on the mountain, magnetite is reported.

A considerable quantity of iron-ore is said to be found opposite Seymour Narrows.

Considerable seams of magnetite traverse the rock on the shore of the Alberni Canal.

Good ore is reported as occurring about 10 miles from Hope.

A vein or irregular deposit of magnetite with iron pyrites is found about half a mile below Nicoamen, but the latter is present in such large quantity as to render the ore valueless.

At Loadstone Mountain, 9 miles southwest of the mouth of Otter River, numerous veins of magnetite traverse an intrusive mass of diorite; those actually observed near the summit of the mountain are about 6 inches in thickness.

At Cherry Bluff, Kamloops Lake, some magnetite of excellent quality is obtained, containing 66.83 per cent. of metallic iron, with very little sulphur or phosphorus. Some veins 3 feet in thickness are found traversing a greenstone mass.

A vein of magnetite said to be 20 feet in thickness is found at Watkinson's, Fraser River.

Clay ironstones in numerous and large nodules are found in several places in the coal-bearing rocks at Skidegate Inlet, Queen

Charlotte Islands; also at Quesnel, in the Tertiary rocks, where it is often converted into hematite by the natural combustion of adjacent lignite-beds.

Hematite is found in considerable quantity, being colored with copper carbonate, at Bull River Cañon, Kootanie Valley. A small deposit is also noticed at Sooke, and some schistose hematite at Similkameen Valley.

Numerous small seams of specular iron-ore are reported at Iron Mountain, near the mouth of Coldwater River.

Iron-Ore Concentration. No. 4.

THE revival of interest in the concentration of iron-ores is more extended than the majority of those interested in iron-ore mining and smelting appreciate, for it is attracting attention in various parts of our own and also in foreign countries. We use the word revival intentionally, as concentration of iron-ores is far from being a novelty, as has been shown in the JOURNAL.

There are to-day three experimental works in operation on a commercial scale, and five permanent plants erected, or nearing completion, for the concentration of American iron-ores by magnetic separation; so that in the near future we may expect to find separated magnetites a permanent feature of the iron-ore supply.

A prominent English metallurgist makes the following comment: "Whether the magnetic separation of iron from the materials with which it is found associated in nature is at present an assured economic success or not, so much has been actually done in this direction as to justify the hope that we shall see applied to ores *per se* as effectual treatment with a view to getting rid of phosphorus and other metalloids as we have already seen applied to the treatment of impure iron by the basic process. We have more than passed the threshold of such a devoutly wished-for consummation, and we may well feel hopeful in reference to the future."

The question of their disposition is not to our mind one of doubt. We naturally anticipate that the prejudice against the use of finely comminuted ore will have to be overcome, but we have faith that a candid investigation will demonstrate the physical condition of the ore to be less of an objection than most iron-workers believe. The "dirt troubles" which are often attributed to the use of fine ore are undoubtedly more "dirt troubles" than "fine ore troubles," and were much of the "dirt" removed from the ores the annoyances would be largely reduced. We have referred to the fact that many blast-furnaces employ as a permanent part of the furnace charge, ore which averages a size no greater than concentrates obtained from lean ores which have been crushed so as to permit of separating the particles of ore and gangue; and we have shown that in one case the amount of concentrated magnetite reached 50 per cent. of the ore-charge of a large blast-furnace; *vide* JOURNAL, Vol. VIII., page 25. We have little confidence in the opinion that the fine ore will be *blown out* of the furnace with the gases, for we see no reason why such should be the case. The blast-pressure is intended to permeate all parts of the crucible, and not cause a strong current at the tunnel-head of the blast-furnace, which will carry off particles of ore of a specific gravity four or five times greater than that of water. (Dana gives the specific gravity of limonite as 3.6 to 4; göthite as 4. to 4.4; hematite as 4.5 to 5.3, and magnetite as 4.9 to 5.2.)

If trouble should arise at the tunnel-head, we believe our blast-furnace managers would speedily find means for correcting it, and this annoyance, if it exists, need be but a temporary one.

The descent of the fine ore in the blast-furnace is another source of anxiety to many, which will undoubtedly be overcome by the method of charging and operating the furnace; and we are strongly inclined to place much of the responsibility for annoyances which have been credited to the use of fine ore to the gangue materials associated with it. If properly charged, ore of nearly uniform size should descend more regularly in the blast-furnace than material varying in size.

The comminution of the ore seems to be an advantage, also, in permitting it to be more readily reduced. Open or porous ores smelt readily because of the ease with which the reducing gases in the furnace can attack each particle of ore, and the consensus of opinion is that all iron-ores are practically reduced to powder before they become metal. If, therefore, ores are placed in a blast-furnace in a condition approaching that which they assume in the lower portions of the furnace, may we not properly anticipate increased results from a plant using them? The amount and character of the gangue of an iron-ore is of great importance to a blast-furnace manager, and one of his constant problems is the fluxing off of the impurities. If, then, these can be be largely eliminated, and at the same time the percentage of iron in the ore increased, there would seem just reason for expecting that a given furnace would require less flux, less fuel per ton of metal, less labor per ton of iron, and less expense handling cinder, as well as less anxiety for the manager, while an increased product from a given furnace would reduce the charges for interest, superintendence, insurance, repairs, etc., per ton of metal made.

We have knowledge of blast-furnaces using fully one-half of the charge of ore which averages as fine as concentrates, and doing unusually good work; and in one case where 40 to 50 per cent. of quite fine ore is employed, the manager is experimenting to remove much of the magnesia and alumina, because he finds that the associated materials forming the gangue and not the comminuted ore causes him trouble. We believe it practical to build furnaces to work all concentrated ore, provided the mixture is not so rich as to produce less cinder than is essential in our present knowledge for satisfactory operation, and we believe that a plant of moderate size would produce as much iron with concentrates as a larger plant with ores in the ordinary condition in which they are delivered to furnaces, thus opening a field for most important investigation.

We are not prepared to assert that in a finely comminuted form magnetite would smelt as easily as hematite in the same condition, for we generally find nature breaks up with reluctance the compounds in which the element to be removed is in the smallest proportion, but we are firm in the belief that a compact magnetite is hard to reduce on account of the difficulty of the reducing gases reaching each particle of magnetic oxide of iron, and therefore claim that concentrates will reduce and smelt more readily than lumps of magnetic ore. Mr. Valentine demonstrates the fact that dense magnetites are troublesome to desulphurize in roasting on account of the sulphur being unable to escape. See his paper on "Roasting Sulphurous Iron Ores," in this issue of the JOURNAL.

We have referred only to the possibility of using concentrated iron ores in the blast-furnace, but attention should also be directed to the revival of interest in direct processes, at least two of which are now being tried upon a commercial scale. Although satisfactory results are claimed to have been obtained in both cases, so many disastrous failures have marked previous efforts that unmistakable ability to make a reliable product and maintain its uniformity must be demonstrated before those interested in the manufacture of iron and steel will look upon the direct process as possibly a large consumer of concentrated iron ores. Good iron sponge has been made by a number of direct processes, but the product was either too costly or too unreliable to command a ready market.

We have discussed in the JOURNAL the reduction of iron-ores by crushers or rolls, and have shown how large a proportion of fines are made. To further illustrate this point, we append two experiments, in the first of which we took part:

In a test made at the Edison Laboratory of Samson (Humboldt, Mich.) magnetic ore which had passed through shaking screens of 20 meshes to the inch, the quantities stated below were refused by sieves of the various meshes given. This ore was reduced by the Gates crusher and Cornish rolls.

Meshes to one inch.	Grammes refused.	Percentage of total.
30	6.060	2.32
40	17.100	6.55
50	8.900	3.44
60	21.500	8.24
70	17.350	6.65
80	12.350	4.73
90	13.500	5.18
100	22.350	8.57
110	12.350	4.73
120	5.700	2.19
150	12.350	4.73
160	24.650	9.45
200	20.500	7.86
finer than 200	66.150	25.36
Total, ...	260.810	100.00

A test made by Mr. W. H. Hoffman at Bayonne, New Jersey, on Croton magnetic ore reduced by a Sturtevant mill, gave the following proportions of sizing:

Meshes to one inch.	Pounds refused.	Per cent. of total.
2 to 6	5¼	30.43
6	1½	8.69
10	1	5.80
16	1¼	7.25
20	1¼	7.25
50	2¾	15.94
No. 60 and smaller,	4¼	24.64
Total, ...	17¼	100.00

We may therefore expect that in crushing ores to pass a certain mesh of screen, that a very large proportion will be finer than the size of mesh, and that for each particular ore the degree of fineness to which it is to be reduced, and the mechanism employed for such reduction, must be a subject for special investigation and experiment. While the finely comminuted character of the results of the two tests above noted may occasion surprise, we believe equal surprise would follow the drying and screening of much of the fine ore now fed to blast-furnaces just as it comes from the mines.

In our next JOURNAL we hope to give some results of the new or remodelled concentrating plants to which reference has been made.

THE EDITOR.

THE Report of Mr. J. S. Jeans, the Secretary of the British Iron Trade Association, for 1888, showed the production of coal, iron-ore, and iron and steel in the United Kingdom in 1888, with other valuable information, compared with the two previous years.

Products—gross tons.	1888.	1887.	1886.
Coal	169,935,219	162,119,812	157,518,482
Iron-ore	14,166,000	13,098,041	14,110,013
Pig-iron	7,898,634	7,441,927	6,870,665
Stocks of pig-iron; Dec. 31st.	2,588,708	2,778,684	2,491,506
Puddled bar	2,031,473	1,701,312	1,616,701
Bessemer steel ingots	2,012,794	2,064,403	1,570,520
Open-hearth steel ingots	1,292,742	981,104	694,150
Bessemer steel rails	979,083	1,021,847	730,343
Tonnage of ships launched	904,329	577,327	481,233
Exports of iron and steel	3,966,984	4,143,028	3,388,494

Weights of Anthracite Coal.

THE *Engineering and Mining Journal* gives an exhaustive table of the weights per cubic foot and the specific gravities of anthracite coal from the different seams of the Susquehanna Coal Company at Nanticoke, Pa., from which the following is condensed:

In 14 specimens taken from the Mills Seam, No. 4 Slope, the specific gravity ranged from 1.421 to 1.490, with an average for the seam of 1.452.

The Hillman Seam, No. 2 Slope, in 11 specimens, the specific gravity varied from 1.443 to 1.517, with an average of 1.4673.

The 6 specimens from the Forge Seam, No. 1 Shaft, had specific gravities running from 1.4555 to 1.541, with an average for the seam of 1.482.

The specific gravities of the 8 specimens taken from No. 2 Shaft of the Twin Seam were from 1.449 to 1.527, an average for the seam of 1.480.

The average for the Buck Mountain Seams, No. 1 and 2 Shafts, was 1.521; the specific gravities of the 10 specimens ranging from 1.496 to 1.540.

The general average for all the seams was 1.4784.

The weights per cubic foot were as follows:

Weights per Cubic Foot of Susquehanna Coal Company's White-Ash Anthracite Coal.

Consisting of about:	Pounds.
45 per cent. from Mills' Seam, average weight per cubic foot, .	90.46
15 per cent. from Twin Seam, average weight per cubic foot, .	92.20
25 per cent. from Ross Seam, average weight per cubic foot, .	93.00
15 per cent. from Buck Mountain Seam, average weight per cubic foot, ...	94.75
100 per cent. all seams, average weight per cubic foot, . .	92.00

From tests made January 27th, 1889, at No. 5 breaker.

Space filled as loaded at breaker without settling. Add 5 per cent for packed spaces or large heaps.

THE Atalla furnace, at Atalla, Etowah County, Alabama, went into blast on June 15th. It is a new charcoal stack, built by the Atalla Iron and Steel Company.

Obituaries.

IT is our painful duty to announce the death of two of the oldest and most prominent iron manufacturers in the country, both members of the United States Association of Charcoal Iron Workers, viz.: the Hon. William H. Barnum and Mr. Silas H. Witherbee.

Hon. William H. Barnum died at his residence at Lime Rock, Connecticut, on Tuesday morning, April 30, 1889, he having been confined to his bed only two or three days.

Mr. Barnum had, however, been feeble ever since his sickness during the late presidential campaign. He was taken sick at that time in New York, and for two weeks it was thought he could not recover. He had been able to ride out for several weeks past up to April 26th, and he was thought to be on the road to recovery.

We had a few weeks prior to his death a business interview with Mr. Barnum, during which we were impressed with his apparent speedy recovery. The remains were buried in the family lot connected with the church and cemetery which he had purchased and donated to the Episcopal Society.

William H. Barnum was born in Boston Corners, N. Y., on September 17, 1818. He received a public school education of a substantial kind. His father, originally a farmer, established the first iron foundry at Lime Rock, Conn., and all his life the son was extensively engaged there and in the neighborhood in the manufacture of pig-iron and car wheels. Many years ago he became interested in iron-ore mines in the Lake Superior region. He was successful as a business man and accumulated a fortune. He figured prominently in politics for many years. In 1851 and 1852 he was a member of the State Legislature. He was elected to the 40th Congress in 1866, and was re-elected to the 41st, 42d, 43d, and 44th Congresses. He served from March, 1867, until May, 1876, when he resigned to take a seat in the United States Senate. His term expired in March, 1879. He has been, however, most prominent as the Chairman of the Democratic National Committee, a position which he held continuously from 1877 until his death.

He was one of the most enterprising and successful iron manufacturers in the country. Early in his life he engaged in the manufacture of charcoal pig-iron in the Salisbury district of Connecticut. At the time of his death he was either sole or part owner of seven charcoal-furnaces in Litchfield County, Connecticut, three charcoal-furnaces in Berkshire County, Massachusetts, and one charcoal-furnace in Dutchess County, New York—in all eleven furnaces, all operated with charcoal, and all using Salisbury ore or ore of similar characteristics. The pig-iron produced from Salisbury ore being adapted to the manufacture of car wheels, led Mr. Barnum to combine the business of manufacturing pig-iron with that of manufacturing car wheels. His operations, however, were not confined to the localities above mentioned. He was at one time engaged in the manufacture of car wheels in Chicago, and he was also a large owner of the Barnum iron-ore mine in the Lake Superior region, and also interested in the Iron Cliff and other mining properties in the same region, and connected with the Pioneer and Pine Lake furnaces in Michigan. It is probable that his interest will continue in the hands of his two sons.

Mr. Barnum joined the Association in 1882, and served on the Board of Managers during the years 1886 and 1887.

Another esteemed member of the Association, whose death we are obliged to record in this number, is Mr. Silas H. Witherbee, who died of pneumonia at his residence in New York City on Saturday, June 8, 1889, leaving a wife and three children.

The deceased was born in Bridgeport, Vermont, on January 27, 1815. Mr. Witherbee's father died when he was but five years old, and he was thus early thrown on his own resources. He obtained his first experience in the iron business as book-keeper for the Port Henry furnaces, afterwards filling a similar position and also managing the Scisco furnace.

In 1848 he moved back to Port Henry, and formed a partnership with his nephew, under the firm name of S. H. & J. G. Witherbee, in the produce and general transportation business, and until 1860 continued in this business, when it was sold.

In 1849 the firm purchased part of the Old Bed mine, at Mineville, Essex County, N.Y., and in 1852 merged their mining interests with those of Mr. George Sherman and John A. Lee, forming the co-partnership of Lee, Sherman & Witherbees. The mining business was then in its infancy, but it rapidly increased with the growth of the industry, and in 1861 the others purchased of Mr. Lee his interests, and formed the co-partnership of Witherbees, Sherman & Co., which name is still held. With the death of Mr. S. H. Witherbee, Mr. G. R. Sherman becomes the senior member of the company and the only surviving member of the original firm.

In 1864, Witherbees, Sherman & Co. purchased an interest in the Port Henry Iron-Ore Company, whose property adjoined theirs, and most of the time since they have represented them as sales agents, the sales of both companies being conducted on joint accounts. A description of the Port Henry mines, of which Mr. Witherbee was a large owner, opportunely appears in this number of the JOURNAL.

In 1852, the Cedar Point Iron Company was formed, and the magnificent Cedar Point furnace built. Later, when the property was purchased by Witherbees, Sherman & Co., Mr. S. H. Witherbee was its president. This furnace was first to use the Whitwell hot-blast stoves in the United States in the manufacture of pig-iron.

There is much in Mr. Witherbee's life to encourage the young man, for his first position as book-keeper for the iron works, of which at the time of his death he was president, was at a salary of $50 per annum and board. His wealth and position were won by conscientious attention to business and strict integrity in all business relations.

It was our privilege to be thrown into business relations with Mr. Witherbee, and each of them attached us more strongly to him. In his death we feel the loss of a friend, and one to whom we would have looked for wise counsel.

Mr. Walter C. Witherbee, son of the deceased, will represent his father's interest in the firm of Witherbees, Sherman & Co.

THE EDITOR.

The Flaxseed-Ore of Wisconsin.

THERE is probably no place in the United States where a large quantity of iron-ore can be more cheaply mined than from the Iron Ridge deposit of Wisconsin, particularly that portion of it which is controlled by the Northwestern Iron Company of Milwaukee.

A ledge of Trenton limestone extends for a considerable distance through eastern Wisconsin, forming a gently sloping table-land, the stone being exposed in nearly vertical faces, protruding from the talus which has been developed as the face of the ledge has receded, owing to the action of the elements. Immediately below this limestone is found a deposit of Clinton Fossil iron-ore, generally occurring in small grains loosely cemented by gangue material. The workings of the Northwestern Iron Company exhibit this deposit in a most advantageous manner, for the capping of limestone is partially, and in some places entirely, absent, while the ore shows a thickness of 30 feet, dipping slightly under the plateau. The adjoining deposits are controlled by the Illinois Steel Company.

The following analyses of the ore will indicate its chemical composition:

ANALYSES OF HEMATITE IRON-ORE, IRON RIDGE, WISCONSIN.

Metallic iron,	51.09	48.82	47.32	50.96
Phosphorus,	1 19	1.21	1.50	1.48
Silica,	5.48	5.66	4.16	4.60
Lime,	2.82	4.77	4.17	4.66
Alumina,	5.27	5.13	6.0	undet.
Magnesia,	2.43	1.31	undet.	2.73
Water,	dried	dried	3.00	dried
Manganese,	undet.	......	trace	trace
Sulphur,	......	......	trace	undet.

The average composition as determined by the furnace yield is:

Metallic iron,	48.3
Phosphorus,	1.3
Silica,	4.5
Alumina,	5.0
Magnesia,	2.0

The ore is practically self-fluxing.

From the above it will be seen that the composition of the ore favors its utilization in producing steel by the basic method, and we believe it will before long be in demand for that purpose.

As mined, or we should say dug,—for mining the ore is little more than excavating a side hill cut in compact sand,—the ore is in lumps; these readily break up in handling, or, if exposed to the weather, "slack" into sand composed of fine grains of red hematite fossil-ore, whose size and color have given good reason for the local name, "flaxseed-ore." These grains are held together by a cementing material which was believed to contain most of the lime, silica and alumina found to be carried by the ore; but some investigations by Mr. F. H. Foote, Superintendent of the Northwestern Iron Company's blast-furnace at Mayville, Wisconsin, appear to prove that the cementing material, as well as the grains of ore, contain most of the component parts as shown by the above analysis. Mr. Foote took samples of the ore for analyses, and then washed portions of them so as to have only the grains remaining with little or no cementing material. The first three determinations were made by three different chemists of the ore as mined—they are marked A1, B1, C1. The next three are analyses of the same samples after washing—A2 being the washed ore from A1, B2 the washed ore from B1, etc.:

ANALYSIS OF IRON RIDGE ORE, WISCONSIN.

	Ore as Mined.			Washed Ore.		
	A1.	B1.	C1.	A2.	B2.	C2.
Iron	50.95	50.10	Undet.	49.40	49.89	....
Alumina	2.27	4.02	4.05	2.14	3.76	3.79
Silica	3.86	4.55	4.38	4.11	4.33	4.35
Phosphorus	1.35	0.81	1.60	1.81	0.85	1.88
Sulphur	Undet.	0.01	Undet.	Undet.	Undet.	Undet.
Lime	"	6.28	"	"	5.66	"
Magnesia	"	1.11	"	"	1.36	"
Volatile Matter Carbonic Acid, etc.	"	11.19	"	"	11.86	"
Moisture	"	....	1.25	"	....	0.67

Analyses A1 and A2 by Davenport Fisher, Milwaukee; B1 and B2 by Union Steel Works, Chicago; C1 and C2 by F. H. Foote, Mayville, Wis.

The tendency of the ore to "run ahead" of the balance of the charge in the blast-furnace encouraged its use with other ores, and satisfactory work was obtained using 50 per cent. of the Iron Ridge ore, although the other ores charged were soft hematites, and consequently composed largely of fine ore.

The location of this deposit, 50 miles north of Milwaukee, 30 miles inland from Lake Michigan and within 20 miles of Fond du Lac, at the head of Winnebago Lake, makes it accessible, and the cheapness of mining will, before long, bring it into demand. At one time a contract for 1,000,000 tons of this ore was made, and nearly 100,000 tons were mined and shipped in a year.

This interesting deposit, of which so little is apparently known by our metallurgists, probably approaches in extent and resembles somewhat the Minette ore of Luxemburg, of which a writer upon the German iron industry lately remarked: "Considerable alterations in the production of ore will be noticed in consequence of the invention of the basic Bessemer process, and it may be noted that the thick deposit of Minette in Luxemburg and Lorraine, which formerly had but a limited use, has attained a high and constantly increasing estimation. According to Mr. A. Jager, Minette consists of fine oolitic grains of brown hematite, cemented together by calciferous, argillaceous or siliceous masses.

"With less than 27 per cent of iron, Minette is not regarded as suitable for smelting purposes. Usually a mixture is employed, which renders the addition of lime as flux unnecessary, and yields 28 to 34 per cent. of iron. For export the higher grade ores are naturally preferred, and the average yield of the Minette exported to the lower Rhine and Ruhr may be taken at 38.5 per cent. of iron with about 10 per cent. of water. The amount of available ore in the Luxemburg-Lorraine deposit is estimated by Mr. Jager at 2,400,000,000 tons, being exceeded in size only by the clay iron-ore deposits of Cleveland. The total cost of production at some of the principal mines in 1881 was found by Jager to be 10d. (22 cents) to 1s. 2½d. (30 cents) per ton, and may now have slightly increased."

The Minette ore approaches in appearance the Iron Ridge ore, as far as the grains are concerned, but the Luxemburg ore has more cementing gangue than the Wisconsin ore, and consequently shows an average percentage of iron below that from the mines which we have described.

If the German and Belgian iron-workers can utilize to advantage the deposit of Minette ore, and find a constantly increasing market for it, we, in this country, should, before long, be able to make a considerable quantity of basic steel from the Iron Ridge deposit in Wisconsin.

In speaking of the supply of ores to German and French blast-furnaces, the President of the British Iron Trade Association says: "Germany has been largely reducing her imports of ore, and her make of Bessemer pig-iron, within recent years. So recently as 1882, the production of Bessemer pig in Germany was 734,000 tons out of a total of 3,171,000 tons, being about 23 per cent. of the whole. In 1888 the production of Bessemer iron had fallen to about 300,000 tons out of a total of 4,229,000 tons, being 7 per cent. of the whole. Germany has very little ore suitable for Bessemer process, having, in 1886, produced only 159,000 tons of pig-iron from home ores of this description, while 267,000 tons were produced from imported Bessemer ores. The future of the German iron industry appears to be identified with the basic process, for the production of which the Fatherland has large deposits of ore, alike in Prussia, in Alsace-Lorraine, and in the adjacent Grand Duchy of Luxemburg, such ores costing on an average not more than 1s. 6d. to 2s. (say from 36 cents to 48 cents) at the mines, and furnishing probably the cheapest raw materials of this description in the world. The production of iron-ores in Germany in 1887 amounted to 9,351,000 tons as compared with 5,457,000 tons in 1878, so that there has been an increase of 3,894,000 tons within ten years."

From an examination of the Iron Ridge ore-deposit of Wisconsin we feel confident that from a portion of it, at least, ore can be won at a cost below that given above for some of the foreign ores.

Like Germany, France has within recent years developed the basic process to a relatively greater extent than England, producing in 1888 some 222,000 tons of basic steel, out of a total output of steel of all kinds amounting to just under 500,000 tons. About one-half, therefore, of the steel now produced in France is made by the basic process. The same remark applies to Belgium, which has, in the adjoining Grand-Duchy of Luxemburg, a practically unlimited supply of cheap ores well adapted for the basic process, which is making decided progress in the country.

In connection with the use of phosphoritic iron-ores we excerpt the following remarks and statistics, from a discussion of "The Basic Process in the United States," by Professor William B. Phillips in the *Engineering and Mining Journal.*

"The increase in the manufacture of basic Bessemer steel or, as I shall hereafter term it, Thomas steel, is one of the most remarkable in the history of the iron trade. Starting with the little 6-pound converter of Thomas, in 1878, this process in ten years has yielded in all more than 8,000,000 tons of steel, rising from 200,000 tons in 1881 to 1,953,234 tons in 1888.

Furthermore, it has enabled the steel-maker to avail himself of ores which ten years ago were unsuitable for his purposes. It has caused the mining of more than 17,000,000 of iron-ore which, but for this fortunate discovery, might have remained hidden within the earth. It has caused the distribution of millions of dollars, bearing in their train the necessaries and luxuries of life. The benefits accruing to the agriculturist from this discovery are scarcely less important than to the steel trade. The production of the 1,953,234 tons of Thomas steel last year was accompanied by the yield of 600,000 tons of basic or phosphate slag, of deservedly high repute as a manure. This slag is sold in New York for $12.50 per ton, and whenever it has been judiciously used it has proved itself to be of superior value, per unit of cost, to many acidulated and super-phosphates.

To exhibit the statistical relations borne by the Thomas process to the regular Bessemer the following table was constructed by Professor Phillips from various sources, chiefly, however, from the *Transactions of the Iron and Steel Institute*, and from *Stahl und Eisen:**

PRODUCTION OF BASIC BESSEMER, OR THOMAS STEEL, FROM 1880 TO AND INCLUDING 1888.

COUNTRIES.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
England	10,000	46,120	109,364	122,380	179,000	145,707	258,466	364,526	408,594
France	....	....	....	....	....	130,582	122,711	174,271	222,833
Belgium	....	....	....	67,106	....	51,514	48,595	60,959	46,237
Germany	....	120,000	......						
Luxemburg	....	....	......	410,052	....	617,514	883,859	1,102,496	1,276,070
Austria	....	....	......						
Other countries	40,000	169,880	340.636	31,835	685,000	....	....	....	....
Total	50,000	336,000	450,000	634,373	864,000	945,317	1,313,631	1,702,252	1,953,234

Taking now the production of both acid and basic steel, and subtracting the total production of basic steel, we will have the total production of acid Bessemer steel from 1881 to 1888 as follows, in tons:

---

* We have corrected some of the figures and added others from statistics lately published by Mr. J. S. Jeans, Secretary of the British Iron and Steel Institute.

	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Acid + basic	4,553,470	5,259,747	5,117,092	4,802,145	5,036,148	6,127,991	7,349,993	6,926,955
Basic	336,000	450,000	634,373	864,000	945,317	1,313,631	1,702,252	1,953,234
Acid	4,217,470	4,809,747	4,482,719	3,938,145	4,090,831	4,814,360	5,647,741	4,973,721
Per cent. of ratio	7.49	8.56	12.39	18.00	18.80	21.50	23.15	28.2

While these figures cannot lay claim to absolute accuracy, they are sufficiently near the truth to allow of some interesting deductions.

The total production of Thomas steel in the United States will not exceed, even if it approaches, 50,000 tons, and now it is not made at all.

The Thomas process succeeds when suitable ores and limestones are used, just as the acid Bessemer demands its own peculiar conditions. The Thomas process is not the universal panacea for ores too high in phosphorus to be used in the Bessemer process. We may have an ore that contains the proper amount of phosphorus and yet fail in carrying the process to success. A high phosphorus ore is only one of the factors of success, for if the basic lining and the basic additions be not suitable the process ends in failure.

The pig most suitable for the manufacture of basic open-hearth steel should have the following composition: Carbon, immaterial; phosphorus, 0.05 to 1.00 per cent.; sulphur, upper limit, 0.10 per cent.; silicon, 0.05 to 1.00 per cent.; manganese, 0.8 to 1.50 per cent.

The composition of the pig most suitable for the Thomas process may be given as follows: Carbon, 2.5 to 3.0 per cent.; phosphorus, 2.0 to 3.0 per cent.; sulphur, upper limit, 0.6 per cent.; silicon, upper limit, 1.5 per cent.; manganese, 1.0 to 3.0 per cent.

THE EDITOR.

IN 1888 there were in Algeria three iron mines which produced 165,209 tons. The iron-ore was shipped to England and the United States.

Iron-Ore Requirements of Great Britain.

WE have received from Mr. Josiah T. Smith, President of the British Iron Trade Association, a pamphlet edition of the paper which he presented before that organization on May 7th, 1889. In this paper Mr. Smith treats of the domestic iron-ore supply of Great Britain and of the foreign sources from which ore is, and can be, obtained for the maintenance of Great Britain's iron industry. Incidentally, he refers to the amount of imports of foreign ore of the United States, France, Germany, and Belgium. He discusses the possibility of maintaining the quality and quantity of ore for many years to come for the European furnaces.

Following the introduction the author first speaks of the domestic supply and then of importations of ore into that country.

"No mineral is of such universal occurrence as iron-ore, and certainly none is so widely disseminated in our own country. We find it scattered over no fewer than twenty-seven counties in England, and it is mined between Cornwall on the one side, and Northumberland on the other. The distribution of the ores, from a geographical point of view, does not, therefore, leave very much to be desired. But there are only six districts where the quantity of ore annually produced approaches or is over 1,000,000 tons, and for all practical purposes the home production of ore may be divided into the two categories of hematite and lias, the former represented by Cumberland and Lancashire, and the latter by Cleveland, Lincolnshire, and Northamptonshire. The three latter districts produce more than 50 per cent., and the former 18 per cent. of all the iron-ore raised in the United Kingdom. Of the lias iron-ore there is practically an unlimited supply. Of hematite, however, the quantity available is more uncertain ; and although it has recently been proved by new discoveries to be more abundant than was at one time supposed, it is doubtful whether the present annual output of about 2,500,000 tons could be largely augmented, or indeed be quite maintained. As it is this description of home ore that is insufficient for our requirements, the sources of external supply becomes not only an important but a pressing question.

"The importation of iron-ores into the chief iron-producing countries of the world may be regarded as dating from about the year 1866, when the Bessemer process had been fairly set on foot. In that year, however, the United Kingdom imported little or no ores, the only European countries that then received supplies of foreign ores being France, Germany, Belgium, and Austria. The united imports of these four countries amounted to nearly 900,000 tons, or one-seventh part of the quantities now imported into the chief iron-making countries from outside sources.

"In 1868 the United Kingdom came into the field as an importer of iron-ores on a scale of some little importance, receiving 88,770 tons from Spain, and 12,073 from Norway, besides smaller quantities from other countries. The total quantity of iron-ore imported into the United Kingdom in this year was 114,435 tons, and the home production was 10,169,000 tons, so that the imports were only 1.12 per cent. of the home production.

"Up to 1877 the total imports of iron-ore into the United Kingdom never, in any single year, exceeded 1,000,000 tons. In the memorable year 1873 they rose to 967,000 tons; but they fell again for some years afterwards, and the trade was practically limited to 1,000,000 tons a year, until, in 1880, it bounded up suddenly from 1,083,000 to 2,634,000, being an increase of over 1,500,000 tons in one twelvemonth. It is somewhat remarkable that this increase should have happened concurrently with the development of the basic process, which was just then coming rather prominently into consideration. In 1882 the imports into Great Britain rose to 3,282,000 tons, which was an advance of nearly 2,250,000 tons on 1879. From this point, however, the movement of the ore import trade was slower until 1887, when the trade took another bound, and the total quantity imported rose from 2,876,000 tons in 1886 to 3,762,000 tons in 1887. . . . ."

The paper is accompanied by a table showing the quantities of iron-ore mined in the United Kingdom, as well as imported into it, and the percentage which the imported ores bear to the domestic for the years 1868 to 1888, both inclusive. From this table we note that in 1868, 10,169,231 gross tons of domestic ore and 114,435 gross tons of foreign ore were consumed in the United Kingdom, the proportion of foreign ores to domestic ores being but $1\frac{1}{8}$ per cent.; and although the domestic production increased rapidly the proportion of foreign ores did not reach 2 per cent. until after 1871. The output from the domestic mines from this date, 1871 to 1878, ranged between 15,000,000 and 17,000,000 tons, but the amount of foreign ores used increased annually with few exceptions, until in 1878 it reached 1,173,860 tons and represented 7½ per cent. of the total domestic ore mined. The maximum output of domestic ore was in 1882, when 18,037,957 tons of ore were raised, and 3,282,000 tons of foreign ores were imported, the imports being 16½ per cent. of the output of the home mines. Since 1882 the production of the domestic mines has declined continually, and in 1888 amounted to 14,166,000 tons. The importation of foreign ores, however, have averaged over 3,000,000 tons, reaching 3,762,000 in 1887, and 3,552,000 in 1888, the foreign ore representing 20 per cent. of the product of the domestic mines.

He next discusses the Bessemer ore resources of continental Europe. The only two countries in Europe other than our own that appear to possess any considerable deposits of iron-ores adapted for the making of high-class Bessemer iron, are Spain and Sweden. Without the ores of these countries our prospects would be worse than they are. Russia has very large deposits of iron-ore, especially in the Ural, but these may be dismissed from our consideration, because they are generally remote from the sea-board, and the cost of transporting them to England, under the most favorable circumstances, would be so serious that it would be impossible to use them with success in competition with the cheaper ores of other countries. Elban ores may also be left out of the calculation, inasmuch as they are becoming scarce, and the total supply now available would not meet our demands for foreign ores for probably more than two or three years. It is possible that additional supplies of ore may hereafter be found in Algeria, but so far as the existing supplies are known, this country is not likely to be of much service to us in the immediate future. We are therefore compelled to place our dependence mainly on Spain and Sweden as external sources of supply.

Concerning the sources of supply of foreign ores, Mr. Smith treats first of Spain, then of Sweden, and presents a table showing the quantities of iron-ore imported in different countries for ten years. Spain is by far the most important source of England's foreign supply, and from this country 91 per cent. of all the foreign ore used in Great Britain was obtained, Algeria following next with 3 per cent., Greece with slightly over 2 per cent. and Sweden and Italy with less than 2 per cent each. A small amount of ore was also obtained from Turkey, Russia, Norway and Portugal.

Another table shows the importations of iron-ore into France for ten years. The ore of Spain is not the most important factor here, contributing but one-fourth of the supply of foreign ores, Germany supplying about five-eighths of the quantity imported and the balance being contributed chiefly by Belgium and Algeria, with a small amount from Italy.

Concerning these foreign ores the author says: "Spain has two districts that are unusually rich in ores of high quality. . . . . . It is a moot-point what quantity of ore remains unworked in the Bilbao district. An estimate made in 1884 put the total quantity of unworked ore in the Sommorostro district at 50,000,000 tons, which would be reduced, if it still held good, to less than 35,000,000 tons at the present time. But farther inland there are still large almost virgin fields of ore, which are computed to add to this quantity 30,000,000 to 40,000,000 tons additional. A part of the latter is, however, of doubtful quality. These two regions together would meet the present demand for perhaps twenty years. . . . . The ores of the South of Spain are virtually untouched, although, so far as can be ascertained, they are of at least as high quality, and probably can be worked fully as cheaply as those of the North. Between Malaga and Carthagena there are some large and easily worked deposits of high-class ores, a few of them running up to about 65 per cent. of iron, and at least one or two of them within 20 miles of the coast. . . . . It is a general characteristic of these ores that they contain considerably more manganese than those found in the North, running up to as much as 4½ per cent., and averaging in some districts 3½ to 4 per cent.; while they exist both as hematites and as magnetites, the former occasionally running more or less into spathic ore. . . . ."

In discussing Mr. Smith's paper, Mr. Barker stated that he should divide the iron mines of the South of Spain into seven groups, namely:

1. Carthagena and Porman,	Hematite and manganiferous ores.
2. Parazuelas,	Red hematites.
3. Aguilas,	Ditto.
4. Garracha and Bedar,	Hematites and maganiferous.
5. Almeria,	Hematites.
6. Malaga and Marbella,	Magnetites.
7. Calasparra and Cehegin,	Ditto.

Of Sweden Mr. Smith says: "The mines in the North of Sweden appear to be those to which attention will be chiefly directed for future supplies to supplement those from the North of Spain. Gellivara (meaning an iron-ore mountain) is about 120 miles northwest of Lulea, which is nearly the most northerly port in the Gulf of Bothnia. Last year Gellivara was connected by a railway with that port, and about 50,000 tons of ore were shipped. The railway is substantially built, and has no gradient more than 1 in 100, while every possible facility is given at Lulea for discharging ore quickly and economically. The load of a mineral train is usually 500 tons, moved in twenty hopper wagons carrying 25 tons each, and this train is taken the entire distance of 120 miles in about eleven hours. . . . . The extent of the deposits in Gellivara and the neighboring mountains is unknown, but undoubtedly enormous quantities of ore exist. The mineral is chiefly magnetic, and, as far as the three openings already made can give any idea of the quality, it may be considered to have from 68 to 70 per cent. of iron—three-fifths of the whole being, however, unsuitable for the ordinary Bessemer or open-hearth processes, in consequence of excess of phosphorus. . . . . The railway pursues its course northwest for 180 miles to Ofoten on the Norway coast, where there is open water all the year round. Sixty miles from Gellivara the two iron mountains of Luossavara and Kunuavara are passed, and these are probably two of the most wonderful iron-deposits in the world. . . . . The analyses of the ores give very much the same results as those shown by the ores of Gellivara, except that the proportion of ore low in phosphorus is very much greater in Luossavara than either at Kunuavara or Gellivara."

Mr. Smith next takes up the conditions affecting the future demands for Bessemer ore and presents some of the data, which we give in another portion of the JOURNAL, and then refers to the influence of the United States, but we are convinced that the author was led astray in some of his data which he makes use of in his paper; as, however, we are now presenting the interesting points in his contribution to our readers, we have no desire to enter into a criticism of his statements.

Concerning the future of British ores, so far as the poorer and more impure varieties of iron-ore are concerned, there appears to be no need for fear as regards our supplies in the near future. The quantities of each description of ore produced in the year preceding the introduction of the basic process and in 1888—a period of ten years—were as follows:

PRODUCTION OF LOW-GRADE ORES.

District.	1878.	1887.
	Tons.	Tons.
Cleveland....................	5,605,639	4,980,000
Lincolnshire................	683,865	1,305,000
Northampton	1,189,443	935,000
Total	7,478,947	7,220,000
Decrease on 1878.............	....	258,947

PRODUCTION OF HIGH-GRADE ORES.

District.	1878.	1887.
	Tons.	Tons.
West Cumberland.........	1,357,886	1,480,553
Lancashire........	984,781	1,192,467
Totals..................	2,342,667	2,673,020
Increase on 1878......................		1,330,353

In the same interval, the quantities of iron-ore imported into the United Kingdom increased from 1,173,000 tons to 3,763,000 tons, being an increase of 2,590,000 tons, or 220 per cent. In reference to price of ores Mr. Smith remarks: "It has been most fortunate for the British iron industry that the iron-ores of Bilbao have been developed with spirit, capacity and intelligence, so that they have been delivered at the furnaces in this country, taking one period with another, at about one-half the price at which the ores of Lake Superior, over the same period, have been delivered at the furnaces in the Eastern States. This has enabled the British ironmaster to produce hematite iron in Wales and Cleveland at approximately about 10s. ($2.44) per ton more than the pig-iron obtained from the impure local ores of our own country, after bringing the ores from a foreign country some 800 miles distant. In the United States, on the contrary, the hematite pig made from Lake Superior ores, on or near the eastern seaboard, has usually cost 20s. ($4.87) per ton, or 50 per cent. more than the corresponding quality of pig-iron produced in our own country: We have been threatened with a mild extent of competition from the furnaces in the North of Spain, which certainly, with their ores costing only 5s. to 6s. ($1.22 to $1.47) per ton at the furnaces, have substantial advantages over our own ironmakers. It is conceivable, also, that, as the iron-ore supplies of Bilbao become further exhausted, the Government of Spain may impose restrictions on further exportations, much in the same way as the Italian Government has done in reference to Elban ores, and in such a case English pig-makers would be driven to other sources of supply, earlier than has been anticipated. The ores of Sweden, and those of the South of Spain, can hardly, in the nature of the case, be delivered so cheaply as those of Bilbao, but they may relatively be more valuable. According to official returns, the average quantity of iron-ore produced per miner is about 631 tons per annum in Luxemburg, 559 tons in England and Wales, 352 tons in France, 228 tons in the United States, and 213 tons in Germany. If we take into account the fact that the average quality of the iron produced in England is much higher than that of Luxemburg, these figures would seem to indicate that we have the cheapest iron-ores of all the great iron-producing countries, even when allowance has been made for differences in the rate of wages.

"Nor is our position less favorable as regards the average cost at which the ores are laid down at the blast-furnaces. In general, the iron-ore mines are less than 30 miles from the place at which they are smelted. This is, at any rate, the case as regards Cleveland, Lincolnshire, Northamptonshire, and the West Coast, which unitedly represent some three-fourths of all the iron-ores raised in the country.

In Continental countries and in the United States no similar advantages exist. Germany brings large quantities of ore from Alsace-Lorraine and Luxemburg to Westphalia and Rhineland. France receives similarly large quantities from considerable distances. Belgium requires to import the bulk of her supplies from Luxemburg. The United States works bring ores distances varying from 700 to 1000 miles. It is true that other elements than that of mere distance enter into the question under consideration. A high-class ore transported for a long distance *may* be much cheaper than a lean ore transported for a short distance. In one country the transport for 100 miles may be relatively much cheaper than the transport for 20 miles in another. But in England we have very little to complain of in either of these matters. Cumberland ore is certainly subject to extraordinary fluctuations, and it is far from agreeable to ironmasters to find the prices of ores jumping up from 12s. to 28s. 6d. per ton, as they did between 1878 and 1880, and falling from 28s. 6d. to 14s., as they did between 1880 and 1881; but in general, our West Coast works have nearly as high a quality of ore as that of the Lake Superior region, delivered at their works for just about one-half of the cost at which that ore is laid down at American furnaces; while even the new iron region of Birmingham, Alabama, is behind our own district of Cleveland as regards the price to the consumer of ores of much the same quality. If the railway companies did as much for English ironmasters as nature has done, our lot would indeed be happy. But with the cheapest ores in the world at command, we have to fight against the dearest transport."

Damage to Iron Works by Water.

THE freshets which prevailed about the 1st of June in the streams emanating from the Allegheny Mountains, did a large amount of damage to iron works in Pennsylvania by flooding ore-pits, or limestone quarries, washing away dams from which power was obtained, and destroying or obstructing by débris, mud or sand, buildings forming a part of some important iron industries. The terrible and unprecedented disaster at Johnstown and neighboring points in the Conemaugh valley, naturally overshadowed the damage to property along the Susquehanna and Potomac rivers, or their tributaries, where quite a number of blast-furnaces, rolling mills and forges were forced to temporarily suspend operations, and in many instances water stood several feet deep in the casting houses of blast-furnaces, or on the floors of rolling mills. In one or two cases blast-furnaces were chilled and portions of mill or furnace buildings wrecked. The dams, which held back the water for supplying power to several forges, were carried away and the buildings and machinery badly damaged. The Cambria Iron Company, at Johnstown suffered severely, the Gautier Steel Department (a large well-equipped rolling mill and wire works) being completely obliterated, and some of the buildings and equipment of the blast-furnaces and steel converting department were damaged or much obstructed by débris.

Independent of the sad disaster to Johnstown and vicinity, the floods were probably unparalleled in this country and the injury east of the Allegheny Mountains was greater than west of them (except in the Conemaugh valley, where the washing away of the dam impounding a large volume of water caused so much havoc).

The heaviest rainfall appeared to be along the eastern slope and on the crest of the Allegheny Mountains, from southern New York, through Pennsylvania into Maryland and Virginia, and iron works along the Susquehanna and Juniata rivers and in the Cumberland valley of Pennsylvania were, with the exceptions mentioned, the heaviest sufferers.

* * *

THE amount of absorbed water in porous iron-ores is less generally appreciated by those who mine, than among those who use them. The laboratory practice which first dries an ore is apt to be misinterpreted by those having ores to dispose of, and consequently occasions surprise when the results are made known. An instance of this is furnished by Mr. E. C. Darley, C.E., who sends the following data concerning some Oregon brown hematites.

	Percentages.					
Iron in ore, natural state, .	33.54	18.29	32.28	41.94	32.40	27.72
Absorbed water, . . .	20.70	....	19.22	10.72	13.66	25.60
Iron in ore (Dried at 212°),	42.32	21.12	39.96	46.98	37.53	37.26
Silica, ...	15.48	....	18.15	18.89	18.15	21.56

The ore in its natural state indicates the percentage of iron in the ore as mined without roasting or dressing in any way.

ADVANCE sheets of the annual report of Mr. E. Costa, in charge of the Mineral Statistics Division of the Geological Survey of Canada, give the following statement regarding the iron and steel production of the Dominion for 1888:

	Tons (2000 pounds).	Value.
Iron-ore,	44,410	$139,393
Pig-iron,	18,191	226,443
Rolled and forged iron,	40,962	1,442,974
Steel,	9,508	470,819

The production of iron-ore has fallen off in recent years. This is particularly true of the Coe Hill mines, owned largely by Americans. The statement as to the production of rolled and forged iron includes four rolling-mills, one forge and the Londonderry Iron Works, but returns have not yet been received from six similar works. Nominally, the value of all Canadian mineral products for 1888 was $16,500,000, as against $12,959,073 in 1887, but in reality $1,847,102 of this increase is a miscellaneous item not included in former returns.

DR. JOHN PERCY, the English scientist and author, whose metallurgical publications are so well known, died at his home in Bayswater, England, June 17th, at the age of 72 years. To Dr. Percy the iron trade owes much of the credit for advancements made, for his critical investigations of plant and method aided to bring those engaged in metallurgy to a realization of the close relations between the technical and practical features of various processes.

THE new charcoal blast-furnace of the Mont Alto Iron Company, at Mont Alto, Pa., was destroyed by fire on the afternoon of April 30th. The furnace had been in operation only about three weeks. Over 200 men were thrown out of employment. The new furnace took the place of one built in 1807–8 and increased in height in 1881. Mr. George B. Wiestling, the superintendent, will have the sympathy of his many friends in the iron trade.

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Magnetic Survey and the Magnetometer.

By ERNEST SJOSDEDT, M.E., *Katahdin Iron Works, Maine.*

[Translated from Prof. Rob. Thalén's paper in *Jernkontorets Annaler* for 1879, and presented at the Tenth Annual Meeting of the United States Association of Charcoal Iron Workers, Duluth, September 23d.]

AMONG the instruments constructed for locating a magnetic ore-deposit, the common *miner's compass* is an old acquaintance, and, in a somewhat modified and improved form, it has been used by Brooks, of Wisconsin, Wrede, of Sweden, and others, for an approximate determination of an ore-vein; but not until Prof. Thalén, of Upsala, had constructed his *magnetometer* and showed us how to use it in the field has it been possible to determine more accurately, and, according to strict mathematical formulas, where most of the ore is located, its depth of centre, its extent, etc.

With the common dipping needle, reliable results can only be obtained when in the hands of an experienced miner, who is well acquainted with the peculiarities of the instrument, and versed in the geology and the mineralogy of the ore-field and its surroundings. As commonly used by "professional" ore prospectors, little reliance can be put in the results obtained, at the best, and at times it may be used fraudulently, as is told of some "experts" who (according to the position of the instrument) could show a "big dip," or a considerably smaller one, at one and the same ore-deposit, depending upon if, at the time, he represented the purchasers or sellers.

Conscientiously and intelligently used, however, a miner's compass is very useful for discovering magnetic ore-deposits, and with the aid of one carefully graded, but not too sensitive, or one so constructed that the needle has a motion in azimuth, as well as in altitude, magnetic reconnaissance maps can be made which will show the extent of the deposit, the direction, and sometimes also the dip, of the magnetic ore-vein.

A few remarks regarding the interpretation of the working of the miner's compass may here be in place. It is easy to understand, for instance, that, as a general thing, there need not be any ore *directly below* the point where the needle stands perpendicular, although it is generally considered that the ore is concentrated here.

The place where the needle is most strongly attracted by a vertical ore-deposit, lies to the *north* of the ore-vein's south pole. For if the magnetism of the ore is sufficiently strong there must be a point somewhere north of the ore-pole where the horizontal components of the terrestrial magnetism and that of the ore must be *equal* in strength, but exerted in opposite directions. In this point, therefore, these horizontal forces neutralize one another, and the remaining vertical forces of the magnetism from the earth and from the ore tend to place the needle in a perpendicular position. Unfortunately, there are two such points on the meridian, and of these the northern one, of course, is the most misleading. This is true when the ore crops out or lies near the surface.

If a shaft were made in such a place, where the needle shows a maximum attraction, it would only be a chance, therefore, to find the ore, as it would happen only when the extent of the out-cropping vein from north to south is sufficiently great.

Again, in the bottom of a magnetic ore-mine the needle shows a strong north-pole attraction. It would therefore be inferred, perhaps, that a new and large vein necessarily were to be found *under* the compass, *i.e.*, that the ore continues down. This need not be the case, however, as the ore *above* the compass is sufficient to explain the vertical position of the magnet, with its north pole down.

It is precarious to try to determine with the miner's compass how deep under the surface the ore is located, as a small ore-vein near the top of the earth shows as strong an attraction on the needle as a large deposit at a greater depth, and in order to fill this want, as well as to get a more accurate instrument generally, Prof. Thalén constructed his magnetometer.

This instrument consists of a common compass-box, with a circle diameter of about 3½ inches, graded in whole and half degrees. And at right angles to the diameter through the zero point the needle-box is provided with a horizontal arm, which serves as a sight when running a line, and carries the fixed magnet in deviation survey—the magnet being placed in a parallel position with the arm, and at an invariable distance from the needle. On the opposite side of the compass-box is a perpendicular socket, in which a bar of soft iron can be placed (for the magnetic dip-determination). The instrument is supported and movable on a vertical axle, provided with spirit level, and mounted on a tripod.

With the magnetometer properly adjusted, the magnet, as well as the said iron bar, causes a deviation of the compass-needle at one side or the other of its natural equilibrium.

The *inclination* of the terrestrial magnetism is thus ascertained with the aid of the iron bar, while the fixed magnet serves to determine the *horizontal* component of said magnetism; and by combination of these observations it is possible also to find the *vertical* component of the terrestrial magnetism.

For determining the *deviation* two different methods can be used: Either the fixed magnet is removed, and the instrument so adjusted that the compass-needle points at zero, after which the magnet is placed on the arm and the deviating angle noted; or the magnetometer is placed so that the needle points at zero when the fixed magnet is in its place, and the deviation read off after the magnet has been removed. Everything else being equal, it is evident that this angle will be larger than in the first case. The former method is called the *tangent*, and the latter the *sinus* method.

When a magnetic ore-field is to be surveyed with the magnetometer, it is first divided up, with the aid of the right arm attached to the instrument, in squares varying, according to the degree of accuracy expected, from 100 to 50 or 25 feet sides, and the *deviations* are observed in each corner of the squares, with the magnet as well as the iron bar. Analogous observations should also be made, both before and after these surveys, so far from the magnetic field that the magnetic attraction does not affect the needle. The magnetic *declination* also ought to be taken, at least approximately. This can easily be done by placing the sight in line with the field lines, removing the magnet and the iron bar, and reading off the degrees of the compass-needle and observing on which side of the north pole the zero point is situated. And, above all, it should be noted all along the magnetic meridian to the north of the supposed magnetic ore-pole, if the north pole of the needle changes direction from north to south, or if it continually points to the north; and, should it reverse, these points must be carefully marked out on the map.

After successively determining the *declination*, the *horizontal in-*

tensity and the *inclination* for each observing point, and the angles having been properly mapped out on the ruled paper, such points of the respective series where *equal* angles have been obtained are combined by naturally curved lines, which, therefore, will show respectively, equal declinations (*isogonic* lines), equal intensity (*isodynamic* lines), and equal inclinations (*isoclinic* lines).

Where there is only one isolated ore-vein, the above construction lines are most generally *closed* curves (circular or elliptical). They group themselves around two certain points, of which the one to the *north* indicates where the *greatest* deviations took place, and the one to the *south* corresponds to the *smallest* angle of said deviation.

Between these groups of curves there is one *open* line, along which the intensity is the same as in a field free from magnetic ore, and which is termed the *neutral* line. The straight line, on the other hand, which combines the maximum and minimum points of the angles goes directly over the ore-deposit, and indicates the direction of its magnetic meridian, and has therefore been called the *magnetic meridian of the ore-field.*

In order to understand the significance of the obtained maximum and minimum values of the above curves, it must be remembered what forces influence the free compass-needle in a horizontal plane, somewhere above the magnetic ore. These forces are the terrestrial magnetism, and the poles of the magnetic deposit (of which the south pole is turned up and the north pole points up). At the deviation with the fixed magnet only the horizontal components of said forces, together with the magnet, are active, however. And supposing that the survey had been made along the field-meridian, in a point south of the ore-vein, then the terrestrial magnetism and that of the ore-deposit will here co-operate, and together aim at retaining the needle in the line of the magnetic meridian, and thus prevent it from deviating far from its original position ; consequently the angle will be *small* and less than in an unmagnetic field where the terrestrial magnetism alone counteracts the fixed magnet. North of the vein, along the meridian, on the contrary, the two horizontal components work in opposite directions, and will therefore neutralize one another more or less; and the fixed magnet will consequently show an *increased* effect, and the angle will grow *larger*. But as said component constantly varies in strength, and in each case for a *certain* distance reaches its *greatest* value, it follows that there must be two points on the meridian (one to the north and one to the south of the south pole of the vein) where also the resultant will reach its maximum and minimum respectively; and the deviating angle will therefore be a true *maximum* at the first place and a *minimum* in the latter case. The isogonic curves consist of concentric ovals which, as a rule, are symmetrically arranged on both sides of the meridian. Each group possesses a point for which the declination is a maximum, and to this corresponds the greatest value of the horizontal component of the ore-magnetism. If the ore-pole is near the surface the said curves project partly on the meridian, and intersect one another. The section point, which is common for them all, is termed the *point of indifference*, because the free needle here has an indifferent equilibrium position.

From the shape and position of the isogonic lines it is possible to determine the position of the ore-pole; and the more or less symmetric form of the ore on each side of the meridian, and its dip is generally indicated by an unsymmetrical shape of the isogonic and the isodynamic curves, namely, so that it dips in the same direction as the curves diverge the most.

For a true interpretation of the curve in each and every special case it is here necessary to refer to the author's mathematical calculations and formulas,* and we must instead confine ourselves to cite a few general rules and conclusions, viz.:

The ore-deposit has to be looked for directly under the place where the neutral line and the magnetic meridian intersect one another.

The upper pole of the vein is located at the point where the field-meridian intersects the neutral line; or at the point of intersection of the meridian and the prolongation of the straight line which combines the two points where an isogonic and an isodynamic curve intersect one another.

The distance from the surface to the center of the ore-deposit is twice as great as the distance, along the meridian, between the vein-point for the deviating intensity angle and the known vertical line through the vein.

When several veins occur in the field the neutral line is winding from the one system to the other, and this line indicates, therefore, through its shape, the presence of another vein.

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* *Jernkantoret's Annaler*, 1879, p. 46, etc.

Spirally Welded Steel Tubes.

By W. S. MALLORY, *of Chicago.*

[Read at the Tenth Annual Meeting (Second Session) of the United States Association of Charcoal Iron Workers, Duluth, September 23d.]

HAVING lately had opportunity of carefully examining the processes and products of a new industry established in East Orange, N. J., which, in my judgment, is destined to exert a most important influence upon the engineering progress of the country for many years to come, I am impressed with the belief that some information concerning it will be of interest to the members of the Association. I refer to the manufacture of serviceable pressure pipes of great strength, from strips of steel, spirally wound and hammer-welded. The process is wholly automatic, and the machinery employed is most ingenious. Considering the number and variety of the operations performed by the machine-feeding in the skelp, bending it, heating it along both edges, hammer-welding the seam, and passing the finished pipe forward, so that its increasing weight shall not overtax the feed devices—it is a marvel of simplicity. A machine which will make 24-inch pipe occupies a space about 3 feet by 6 feet, and is run by a 3-inch belt. To watch it in operation and see cold steel entering the machine in a flat ribbon and black pipe, perfectly welded, straight, smooth and beautiful, passing out a few inches further along, is indeed a surprise, especially when it is realized that within this few inches the pipe has been formed, the metal brought to the welding heat, the welding accomplished and the seam cooled by water.

The steel used in this industry is of very mild quality and, from its chemical composition, weldable. It is made in the Bessemer converter and gives the following average analysis:

Carbon,	.07
Silicon,	.003
Sulphur,	.048
Manganese,	.318
Phosphorus,	.120

This material has an average elastic limit of 43,000 pounds, and an ultimate strength of 63,000 pounds. It welds perfectly. For the purposes of this industry it is rolled in strips of the greatest practicable length, 12 or 18 inches wide. These strips average 20 feet in length. To prepare them for use in the production of long tubes, the ends of these strips are lapped and welded together by machinery adapted to the purpose.

The end of a strip thus prepared is secured to the guide table of the pipe machine, which is set at the angle due to the relation between the width of the skelp used and the diameter of the pipe to be made. It enters flat, impelled by feed rolls which are geared together, and are adjustable to any thickness of skelp employed. As the skelp enters it passes over the face of a stationary, water-cooled anvil—or, more properly, anvil-horn—which, being smaller than the pipe, does not in any respect serve as a mandril. The face of this anvil is slightly curved, and the side next the furnace, which is always exposed to intense heat, is protected by a face of refractory material conforming to the curvature of the pipe. The formation of the pipe is effected by a device known as the crimper, which is an oscillating curved jaw, acting against the face of the anvil, and bending to the required radius the steel interposed between them. After receiving its bend the steel is kept in place by the former-block, lined with rolls, and it is there kept from springing out of shape until it is welded.

The welding heat is supplied by blow-pipes of water, gas and air, contained in a small furnace scarcely more than a foot square. One heats the upper or entering skelp, and the other the lower skelp, or that portion which has already taken the form of the pipe. The feed brings these edges together as the pipe rotates and grows, and a rapid-striking, light hammer welds the two edges together as they meet on the anvil. The feed is variable, at the pleasure of the operative, and may be reduced or increased as the color at the point of welding renders necessary. He has his gas and blast perfectly under control, and can vary their proportions as he finds necessary. With this exception, the machine is entirely automatic in operation. The emerging pipe is sustained on supports with trailing anti-friction wheels, which accommodate themselves to its double motion; and when finished it requires only to have its ends cut square and its couplings applied. Any length of pipe can be made which it is possible to handle when finished. The longest piece thus far made was 57 feet in length, 10 inches in diameter. It had to be cut up for shipment.

These tubes combine lightness with strength in a degree never before attained in pipe manufacture. The reason for this is obvious when it is remembered that the weld is a spiral re-enforcement. A circumferential strain, which exerts itself to open a longitudinal weld, only closes a spiral seam the more tightly. It is impossible by any pressure yet applied to open a spiral seam; and even if the welding is imperfect, as sometimes happens with too rapid feeding, the effect of internal pressure is to close the leak and not to open it. One is naturally surprised to learn that a pipe which will show a leak at 20 pounds of water pressure, becomes as tight as a bottle under a pressure of 100 pounds, and stays so until the ultimate strength of the metal is reached. Yet such is the fact. The explanation is found by a simple experiment. With a strip of paper wound spirally and pinched tight at one end, a light pressure of the breath, applied with the mouth at the open end, will find easy escape, but as the pressure increases the leaks close, and the pressure may then be increased until the tube bursts. The harder you blow the tighter it becomes. The tendency of the spiral to unwind has produced such close contact at the seams that a leak is impossible, even though tightness depends solely upon the mere contact of paper surfaces. As a rule, however, the spiral welds are perfect, and as soon as the ends of the tubes are squared they are tested to 300 pounds, and passed into the finishing shop, where they are flanged or otherwise prepared for use.

The actual strength of this pipe is never indicated by the tests applied at the mill, unless it is desired to surprise a visitor. They are then tested under pressures ranging from 500 to 1000 pounds per square inch, according to weight and diameter. A pipe has never been burst by any means yet available in testing it. As indicating the strength of these tubes, I take the following illustrations at random from the test records:

Diameter.	Weight per foot.	Safe under pressure.	Ultimate strength.
6 inches.	6.22 lbs.	866 lbs.	1408 lbs.
12 "	15.41 "	727 "	1181 "
16 "	26.19 "	670 "	1088 "
20 "	32.25 "	536 "	871 "
24 "	38.78 "	446 "	726 "

For these comparisons I have taken neither the lightest nor the heaviest pipes made by this process, but those of medium weight. The ultimate strength in each instance is calculated, and is that due to a seamless drawn steel tube of the same weight and diameter. In point of fact, however, the spirally welded tubes are stronger than seamless tubes would be. The spiral lap is equivalent to a re-enforcing band around the pipe. As I have already said, they have never been burst by any pressures at the command of the makers. Captain E. L. Zalinski, while in charge of the pneumatic gun experiments at Fort Lafayette in New York harbor, undertook to burst a light 10-inch tube with compressed air which he had under a pressure of 2000 pounds per square inch. The pipe prepared for this test was flanged, and the ends closed by cast-iron discs bolted on. In the first trial the bolts stripped under a pressure of 750 pounds, and the discs flew off. The holes were then reamed out for $\frac{7}{8}$-inch steel bolts, and the pressure run up to 850 pounds per square inch. At that pressure the cast-iron flange went to pieces, but the pipe showed no evidence of having been under test. Captain Zalinski then asked that extra heavy steel flanges be prepared, as he was anxious to see what the pipe would carry, but before they could be made he was sent on his military mission to Russia. It is to be regretted that this most interesting test was never carried to a conclusion, but in view of the fact that the pipe under experiment, though of 10-inch inside diameter, was only .083 inch thick, and weighed less than 10 pounds to the foot, it will be conceded without argument that it developed a strength unprecedented in pipe manufacture. It shows very clearly that the weight of metal found in lap-welded pipes is not put there for strength, but to re-enforce the longitudinal weld, which is always a line of structural weakness.

Spirally welded steel tubes are suitable for every use for which pressure tubes are employed, but their most conspicuous advantage, other than relative cheapness, is found in the fact that their average weight is $\frac{1}{5}$th that of wrought-iron, and $\frac{1}{10}$th that of cast-iron. They are now made in diameters ranging from 6 inches to 24 inches, and machines are being designed which will make 48-inch pipe from steel $\frac{1}{4}$-inch thick. These will be used for boiler shells, petroleum tank-cars, and other uses for which riveted cylinders have hitherto been employed.

The novel industry which I have thus briefly described places a new material at the command of the engineer, which is already in such demand as to embarrass the makers in filling orders. Its principal uses thus far have been for natural gas lines, conduits for compressed air, pump columns and discharge pipes in mine drainage; steam, blast and gas conduits in metallurgical works and water mains. The couplings are as practical as the pipe. Those most used are the flange and the hub and spigot, made to the American Water Works standard for cast-iron pipe. All forms of flanged or hubbed specials are used as with other pipe.

The development of this industry is due to Mr. James C. Bayles, of New York, well-known to most members of this Association, and who some years ago was recognized by his election to an honorary membership. The patents for the United States and Canada are controlled by The Spiral Weld Tube Company, of which Mr. Bayles is president and general manager. Its works are located at East Orange, N. J., but the demand for the product is so great, that already the question of locating works in the West and South, as well as on the Pacific Coast and in Canada, has been forced on the consideration of the company. It is the most interesting and important mechanical development of which I have knowledge; and in view of the increasing demand for large pipes, it enjoys the advantage possessed by few new industries—of finding its market already created.

DISCUSSION.

Mr. GEO. W. COPE, Chicago, referred to some details in the machinery which forms the pipe, and expressed confidence in the value of the product for most or all the purposes for which iron tubing is applicable.

MR. A. E. NOBLE, Jenifer, Ala., said that he had seen the pipe in use, and esteemed it highly. He also described the coupling which he recognized as a " very ingenious device."

Mr. JOHN BIRKINBINE, Philadelphia, Pa., cordially coincided with Mr. Mallory in his statements concerning the ingenuity of the device for producing the spiral weld pipe, and also the apparent perfection in form which has been achieved. A visit to the works where the pipe is made impressed him most favorably as to the merits of the tubing, and there seems no reason to doubt the remarkable strength which it develops under test. The question as to durability will naturally arise, but from the figures given it is evident that a liberal allowance for loss by rust can be made, and still supply a light, strong pipe. These pipes seem well adapted for conveying steam or compressed air, and with non-conducting lining (which is now supplied) they are adaptable for mine drainage, and experiment will soon demonstrate their utility and durability when buried in the earth.

Blast Furnace Records.

THE very satisfactory operation of some of our charcoal blast-furnaces encouraged us to make an attempt to present to our readers some reliable data, showing their average product in tons of iron made, the average fuel-consumption, etc., and we have asked permission of some of our blast-furnace friends to give to our readers an authentic statement of the furnace-operations for a term of years, our desire being to present them in the JOURNAL. In justice to those who favor us with these figures, we emphasize the fact that they are given at our urgent request upon the assurance that they would be of material assistance to the iron trade. We hope to add other records to those herein given.

The first which we shall present to our readers is the record of a phenomenally successful blast-furnace erected on Spring Lake, a feeder of the Grand River, Michigan, through which the plant has water transportation from the ore-shipping points to docks immediately alongside the stock-house. This furnace is located near the eastern shore of Lake Michigan, about 10 miles from the city of Grand Haven. It has both rail and water-communication. We are indebted to Mr. Joseph C. Ford, manager of the Spring Lake furnace, for the following data:

"*The Spring Lake Iron Company's Furnace at Fruitport, Mich.*, was constructed in 1879–80, first blown in March 4th, 1880, and is now on the sixth blast. From time of blowing-in of furnace to September 7th, 1889, a period of 3471 days, the furnace has run

3205 days (about 8¾ years). The length of various blasts and the results obtained in each are as follows:

	Length of Campaign. Total days.	Stops.	Net days.	Gross tons of pig-iron made.	Tons of pig-iron per day.	Bushels of charcoal per ton of iron.
1st Blast,	677	7	670	29,040	43	94
2d "	799	7	792	33,124	42	95
3d "	331	11	320	15,279	48	89
4th "	510	14	496	26,868	54	88
5th "	586	10	576	29,237	51	92
6th "	361	10	351	20,451	58	95
	3264	59	3205	153,999	48	

"The iron is weighed out at 2260 pounds to the ton. The charcoal is charged to furnace by measure, 2748 cubic inches to the bushel, the weight averaging 20 pounds. It is made from one-third hemlock, black ash, elm and soft maple, and two-thirds from beech, sugar maple, oak and birch woods, in brick kilns owned by the company, 20 of which are of 80 cords capacity, and 30 of 55 cords capacity each.

"The furnace is 45 feet high, bosh 10 feet 6 inches in diameter, with crucible 5 feet in diameter and bell 5 feet, equipped with Weimer charger and seal. It is blown by a Weimer engine, 60-inch air-cylinder, 4-foot stroke. Steam is supplied by two batteries of steel boilers (two boilers in each battery). Boilers 30 feet long and 48 inches in diameter, one battery only being used at a time.

Blast is heated by one 24-pipe Player and one 35-pipe Weimer suspended stove; the average temperature of blast being 850°, as blown into furnace through four 3½-inch tuyeres.

The ore used is brought from Lake Superior mines by rail to Escanaba, thence by vessel to Fruitport, and discharged directly into the stock-house adjoining the furnace. The limestone used for flux is brought from Kelley's Island, Lake Erie, by vessel. The fuel-supply is obtained at and near to the furnace, along the line of Chicago and West Michigan Railway, 40 miles being the longest haul of charcoal by cars. The average yield of the ore-mixture varies between 58 and 61 per cent.

The second record which we present is of

The Hinkle Furnace of the Ashland Iron and Steel Company,

Located at Ashland, Wis., on the southwestern end of Chequamegon Bay. It uses entirely Lake Superior (Gogebic Range) iron ores. A full description of the plant will be found in the transactions of the Tenth Annual Meeting in this issue of the JOURNAL.*

The furnace is 12 feet in diameter at the bosh and 60 feet high, equipped with two fire-brick hot-blast stoves, each 18 x 60 feet, which heat the air to a temperature of about 900 degrees.

We are indebted to Mr. Morris R. Hunt, General Manager of the Company for the following data:

"The furnace was blown in April 4, 1888, and blown out June 30, 1888. During this time it made 3261 gross tons of pig-iron. The actual days working, were 73, and average daily output 44.67 gross tons of pig-iron.

"It was again blown in August 21, 1888, and blown out August 1, 1889. During this period it made 26,137 gross tons pig-iron. The actual days working numbered 316, and average daily make 82.71 gross tons of pig-iron.

"It was again blown in September 9, 1889, and up to date has made an average daily run of 90 gross tons."

We hope to supplement the data presented by Mr. Hunt by other figures, giving fuel consumption, yield of ore, etc.

Narrative of the Tenth Annual Meeting.

WE chronicle another successful and interesting meeting of the United States Association of Charcoal Iron Workers, a fitting close for its first decade of existence. The sessions were unfortunately restricted, and some which had been arranged for were dispensed with because of the unstinted hospitality of friends who desired to add to the pleasure and profit of those who attended. Several proffered courtesies had to be declined, and every hour of the nine days was fully occupied.

No more favorable time could have been selected for a visit to the Lake Superior mining districts than near the close of their greatest shipping season. As the Marquette and Menominee ranges had been visited in 1883, the original intention was to examine only the newer Gogebic and Vermilion ranges, but the programme was finally modified to include a flying visit to the Chapin mine. For the benefit of our readers we present a synopsis of the meetings and excursions; the papers and discussions will be found elsewhere.

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* See page 278.

FIRST DAY.

A party of ladies and gentlemen, numbering about forty, reported at the Plankinton House, Milwaukee, on Tuesday, September 17th, and in the evening gathered in the Athenæum, to listen to President Bean's address of welcome. The Athenæum is a unique institution, a club house, managed exclusively by ladies, which has thus far been very successful.

The Secretary presented his report showing the present membership and financial status of the Association; and afterwards exhibited some specimens of New Bed magnetite from the mines of Messrs. Witherbees, Sherman & Co., at Port Henry, N. Y.

Papers were read by Mr. Edgar S. Cook, of Pottstown, Penna., on "Unreduced Ore Passing Through the Blast-Furnace," and Mr. Victor O. Strobel, of Philadelphia, on "The Development of the Fire-Brick Hot-Blast Stove," and after these had been discussed the meeting adjourned.

Mr. Cook's paper appears in the JOURNAL. Mr. Strobel's paper is deferred until our next issue.

SECOND DAY.

The party assembled at the Union depot, and boarded a special train furnished by the courtesy of the Chicago, Milwaukee and St. Paul Railroad Company, for a run of 50 miles to Mayville, Wis., to inspect the Mayville blast-furnace, which is now leased from the owners (The Northwestern Iron Company) by the Illinois Steel Company, who are experimenting, producing pig-iron from "flax-seed" and Menominee ores, using coke as fuel. The possibility of utilizing the metal for making basic steel is under consideration.

THE MAYVILLE FURNACE.

The original furnace was built in 1848 to smelt the local ores with charcoal, and, as the ore was self-fluxing, no limestone was used.

The present furnace, which is now in blast making coke foundry iron, is 67 feet 7 inches high, 13 feet 6 inches in diameter at the bosh, and is furnished with a 6-foot bell. The entire bosh and the crucible are protected by bosh-coils, water-jackets and water-boxes; air is supplied by a Weimer blowing engine (having an air cylinder 72 inches in diameter, a steam cylinder 32 inches in diameter and 4 feet stroke), through 6 tuyeres which are fitted with cinder relief valves.

Four double boilers, 42 inches in diameter and 36 feet long, each with 2 to 14-inch flues, with lower boilers 36 inches in diameter and 26 feet 6 inches long, supply steam.

The air is heated in three 24-pipe Weimer suspended hot-blast stoves.

A mixture of 30 to 40 per cent. of flaxseed-ore, on a charge of Lake Superior soft ores, is used. A double-hoist inclined plane conveys the charge to the tunnel head-level.

The present output of the furnace is about 50 tons per day.

A visit was also made to the neighboring deposit of flaxseed-ore at Iron Ridge, which impressed all by its magnitude and the low cost at which it can be worked. This interesting deposit was fully described in the JOURNAL, vol. viii., page 244.

BAY VIEW IRON WORKS.

On returning to Milwaukee, a visit was made to the Bay View Works of the Illinois Steel Company; Mr. Francis Hinton, Manager, and a number of the superintendents of various departments escorted the visitors through the plant. There are two blast-furnaces, each 16 x 60 feet. Only one of these was in operation, turning out about 1100 tons of foundry iron per week. The other stack is being remodeled and equipped with a set of three Massick & Crooke, 18 x 65 feet fire-brick hot-blast stoves, similar to those in use at the active furnace. It will be blown in shortly. Air is supplied to the furnaces by two Robinson Rea Manufacturing Company's and one Cuyahoga engine. Another Cuyahoga engine is now being put in place.

The rolling mills were also visited, and the process of manufacture of angle and bar iron watched with interest. A machine for making the joint plates for rails, and punches for punching holes in the same, were examined.

In the Merchant mill, 160 feet wide and 300 feet long, the boilers are run entirely with oil, brought through pipes by gravity, and fed through burners, from the tank cars which are on elevated tracks. Mr. Hinton stated that he was thus enabled to secure a greater uniformity of heat and produced more steam with less labor, thus offsetting the increased cost of the oil. The gas for heating furnaces is made in Siemens gas-producers. A walk through the warehouse with its store of angles, bars, shapes, etc., completed the visit.

After dinner a committee of the citizens of Milwaukee, headed by the mayor, escorted the Association to the Milwaukee Industrial Exposition, where unusual courtesies were offered. The exhibition is a credit to the city and the visit was much enjoyed by all.

THIRD DAY.

MILWAUKEE.

In the morning the Reliance Works, of Messrs. E. P. Allis & Co., were inspected, and the foundries, machine shops, erecting works, etc., were found to be in a state of great activity. The principal features of interest seemed to be two blowing engines for the Illinois Steel Company. A large hoisting drum and the overhead travelling cranes operated by electricity, also attracted attention.

The afternoon was fully occupied by a drive about the city, carriages being furnished by the Advancement Association, of Milwaukee, which also supplied maps and books in which the industries and beauties of Milwaukee were fully set forth. Passing through Juneau Park and Prospect Avenue, along the lake-front, the Milwaukee River flushing tunnel, the water-works, and the handsome water-tower were visited; then continuing through the principal thoroughfares to the State fair, which was in progress. The drive terminated with an examination of the extensive grounds of the National Soldiers' Home. Leaving Milwaukee in the evening, on the Wisconsin Central Railroad for Ashland, Wisconsin, all went away delighted with the "Cream" city and with those of its quarter of a million citizens who had the opportunity to show their good will.

FOURTH DAY.—ASHLAND, WIS.

On arriving at Ashland, in special sleeping cars, a delegation of citizens escorted the party to the Chequamegon House, and, after breakfast, provided carriages to visit the handsome plant of the Ashland Iron and Steel Company.

THE HINKLE FURNACE.

The ore is run into a stockhouse 62 feet wide, 150 feet long and 32 feet high, on two elevated tracks passing through the building into an annex, where charcoal is stored for emergencies, that for daily use being taken from the cars direct and put into charging-buggies. Immediately back of the stock-house, and within a short distance is the hoist-tower, a brick structure, 85 feet high, in which is an Otis hoisting-engine. The stack is a taper-shell, 60 feet in height and 12 feet in diameter at the base. The air is supplied by an Allis engine, with 72-inch air-cylinder and 48-inch stroke, to two Whitwell fire-brick hot-blast stoves, each 12 x 60 feet, where it is heated to an average temperature of about 900 degrees.

The casting-house has been enlarged on account of the increased output, and is about 52½ feet wide and 152 feet long. The furnace was not running to its full capacity, its yield being 80 to 85 tons per day of foundry iron, while during the former blast the production at times exceeded 100 tons per day, and, on one occasion, Mr. Hunt states that 122 tons were made. About 85 bushels of charcoal and 1¾ tons of Lake Superior ore were used to make a ton of pig-iron. Steam is furnished by three batteries of Heine water-tube boilers. We publish the record of the furnace in this issue under the caption " Blast-Furnace Records."*

ORE DOCKS.

The party next proceeded to the ore docks of the Milwaukee, Lake Shore and Western and the Wisconsin Central railroads, the first named having two docks, and the latter, one. The Milwaukee, Lake Shore and Western docks are each 1400 feet long, and have 234 pockets, with capacities of 24,000 and 30,000 tons respectively. The Wisconsin Central Railroad dock is 1404 feet long, and has a capacity of 28,250 tons. The combined capacities of the three docks would supply a blast-furnace for an entire year which makes 150 tons of pig-iron daily. The bulk of the ore from the Gogebic Range is shipped from these docks, but some of it goes to Escanaba, and some by all-rail to western blast furnaces. The total amount shipped in 1889, up to September 18th, was 1,170,640 tons. The ore is brought in 20-ton-ore cars, and dumped into pockets on either side of the dock, from which it is loaded into vessels in the usual manner, by chutes which can be raised or lowered. Each pocket when filled with ore is labelled, so that there will be no error as to crediting the mine from which it came. A vessel has been loaded here with a cargo of, say, 2000 tons of ore, in from five to six hours.

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* *Vide* page 274.

CHEQUAMEGON BAY.

In the afternoon, through the courtesy of the Citizens' Committee, a delightful steamboat excursion was given on Chequamegon Bay, during which an interesting visit was made to the quarries of the Prentice Brownstone Company, where the sandstone lies nearly horizontally, and is readily cut by steam channelers, and then split off at the desired depth by means of steel wedges. This stone, which is soft on being quarried, hardens on exposure to the air.

At La Pointe, a small village on Madeleine Island (one of the Apostle Islands), the old church, which was stated to have been erected by Father Marquette about the year 1669, was inspected.

In the evening, the business men of Ashland tendered the Association a reception which was most cordial and friendly, ending with an excellent banquet at the Chequamegon House: covers were laid for 140. Mayor H. H. Beaser presided. The address of welcome was made by Dr. Edwin Ellis, and replied to by President Bean and Secretary Birkinbine. The hour being very late, it was decided to dispense with the other speeches, and the banqueters dispersed.

FIFTH DAY.

On Saturday morning the Association left Ashland for Duluth, Minn., carrying with them a good impression of the free-hearted hospitality which they had received, and a firm belief in Ashland's future.

WEST DULUTH, MINN.

After luncheon at the Spalding House, Duluth, the party was conveyed by the St. Paul and Duluth Railroad to West Duluth to visit the blast-furnace plant of the Duluth Iron and Steel Company, nearly completed. The furnace stack is 16 feet in diameter at the bosh, and 76 feet 7 inches high. It is equipped with a special Weimer charging apparatus, and stands in a cast-house built of brick, the inside dimensions being 62 feet x 130 feet 7 inches, and 22 feet high to the square of the roof. Air will be supplied by a Weimer 4 x 7½ feet engine, steam cylinder 42 inches in diameter, and heated in three Gordon Cowper Whitwell fire-brick hot-blast stoves, 18 feet in diameter and 60 feet high. The engine-house, which is 61½ x 42 feet, and 34 feet high, has room enough to accommodate two additional engines when the plant is enlarged, and all the different portions of the plant are so arranged that a twin blast-furnace can be added. Steam will be supplied by two batteries each of four combined, double-flue and cylinder boilers. The upper boilers are 48 inches in diameter and 35 feet 10 inches long, with two 16-inch flues, and the lower boilers, 42 inches in diameter and 28 feet 8 inches long. The draft-stack is of brick, 132 feet high and 7 feet square inside.

The ore and stock-shed is 120 feet long and 42 feet wide; the stock being carried from the stock-house floor level to the furnace top in an automatic skip-car, running on an inclined plane, 325 feet in length. This car will hold 2 tons of coke, or 5 tons of ore.

The fuel used will be coke, which is to be made on the ground, from Pennsylvania bituminous coal, thus avoiding any loss by breakage in transportation. If this is obtained at or near Chicago prices, as is expected, the furnace could save a large proportion of the ore freightage, and should be able to make pig-iron at or below the cost at Chicago.

The Minnesota Iron Car Company's works, adjoining the Duluth Iron and Steel Company's, was next inspected. The foundry is 61 x 385 feet, the rolling-mill and forge-building 30 x 300 feet. The erecting and machine shops and planing-mill are under one roof, the dimensions of the building being 97 x 527 feet. The paint shop is 58 x 362 feet.

The cupola made its first heat on the day of the visit, and some plates for the rolling-mill were cast. A system of overhead trolleys for handling ladles and castings, attracted attention.

The Minnesota Iron Car Company is reported to have a number of orders on hand, some of which are from the Iron Car Company of New York, with which it has close relations.

DULUTH.

Returning to Duluth, a visit was made to the ship-yard of Captain Alexander McDougall, whose patent cigar-shaped vessels have proven to be an innovation in lake transportation. One of these, "103," was on the stocks nearly completed. This vessel or barge, which has no motive-power of its own, is 36 feet beam, 260 feet long, and 22 feet deep, and can carry a cargo of 2700 to 3000 net tons, drawing 15 to 16 feet of water. The ends of the vessel taper nearly to a point, and at the stern is a straight stern-post, which carries the rudder. It has a double bottom, with compartments, which can be filled with water to act as ballast when the vessel has no cargo. It sets low in the water, and it is claimed that the waves will break over it; but as it offers little resistance, and the hatches are battened down, no damage is expected; it is also easier to tow. On the deck are two circular turrets, one being on the forward part, the other aft, which act as quarters for the men. This is the third vessel built on this model, and others are contracted for.

Through the courtesy of the citizens of Duluth, a steamboat ride on Superior Bay was provided, and after inspecting one of the large elevators where a steamer was being loaded with wheat, skirting the water-front, and obtaining a panoramic view of the coal docks, elevators, wharves, etc., which front on the beautiful Bay of Superior, the boat passed through the channel which has been cut through Minnesota Point out on to Lake Superior, where a magnificent prospect of the city of Duluth, rising from the water and nearly reaching the top of the hill on the side of which Duluth is built, was obtained, and then returned to the city.

In the evening a planked white-fish dinner was tendered to the Association, at the Spalding House, Mr. Wm. F. Phelps delivering the address of welcome, which was responded to by President I. M. Bean on behalf of the Association. Speeches were also made by Justice Cox, Jr., of Philadelphia; W. H. H. Stowell, Secretary Duluth Iron and Steel Company, and J. W. Nesmith, of Denver, Colo. But host Emerson made the most lasting impression by his superb fish.

SIXTH DAY.

Sunday was passed quietly, according to the established custom of the Association.

SEVENTH DAY.

VERMILION IRON RANGE.

Monday, the party, accompanied by representatives of Duluth's business men, occupied a special train tendered by the Duluth and Iron Range Railroad, which, after a run of 27 miles, stopped at Two Harbors, where the ore-docks and the railroad company's shops are located. The two docks are about 1100 feet long, and have an aggregate capacity of about 35,000 tons. The next stop was at Tower, 70 miles from Two Harbors, where the famous mines of the Minnesota Iron Company are located. Eleven openings were visited in succession, and the party also enjoyed a beautiful view of Vermilion Lake, with its 400 islands and the surrounding hills. These mines were described in the JOURNAL, Vol. VII., p. 228, but since then the annual output has been increased; 394,252 tons being shipped in 1887, 457,341 tons in 1888, and Mr. D. H. Bacon, the general manager of the company, stated that nearly 525,000 tons had already been shipped this season up to September 23d. The lowest level now being worked is 300 feet from the surface.

ANALYSES OF MINNESOTA IRON ORES.

The following table shows the average analysis of samples taken from the cars on their way to the docks during the season of 1889:

Months.	Iron.	Phosphorus.
April,	68.29	0.039
May,	67.07	0.048
June,	67.70	0.050
July,	67.56	0.051
August,	67.58	0.049
Average,	67.64	0.047

Six grades of ore are made at the Minnesota Iron Company's mines, which are sold upon their composition as follows:

		Iron.	Phosphorus.
Minnesota,	Bessemer Ores,	67.00	0.055
Braddock,		65.00	0.055
Nipegon,		62.00	0.055
Vermilion,		67.00	0.090
Soudan,		65.00	0.090
Red Lake,		62.00	0.090

All of these determinations are made when the ore is dried at 212 degrees Fahrenheit.

The present workings are from 130 to 200 feet deep, but the diamond drill shows ore at 450 feet depth.

Returning to the train, a run of about 23 miles was made to Ely, during which a lunch was served by the courtesy of the Chamber of Commerce of Duluth, and on arrival at Ely, the Chandler mine was visited.

The Chandler ore has practically the same general chemical composition, but differs in its physical characteristics from the Vermilion ore of the Minnesota Iron Company. The Chandler ore seems to have been crushed into small pieces by some tremendous grinding process or convulsion of nature.

The company had thus far this season shipped over 250,000 tons of ore; last year it shipped 54,612 tons.

The ore is a high-grade Bessemer, and Col. James Pickands said that "the vein has been proved for a length of over 1000 feet, a width of over 200 feet in place, and a depth of 100 feet, showing at every point of test a high-grade Bessemer ore." Analyses are as follows: A being a selected sample, B the shipping average of Chandler ore dried at 212 degrees.

ANALYSES OF CHANDLER ORE.

Metallic Iron.	Phosphorus.	Silica.
A, 69.00	0.018	0.82
B, 66.79	0.036	4.07

The uniformity of composition of the Chandler ore is remarkable. We saw analyses of over 40,000 tons of the high-grade ore, which in no case showed a variation of 1 per cent. in metallic iron, or over .003 of one per cent. of phosphorus.

The mine was developed as an open pit, and much of the ore obtained has been won from this opening. Operations are now also carried on underground, the caving system being adopted.

The mine is leased by the Chicago and Minnesota Ore Company, on a royalty of 40 cents per ton for the first 100,000 tons, annually mined, and 30 cents for each additional ton. Capt. Joseph Sellwood, who took nearly 900,000 tons of ore from the Colby mine, is General Manager, and Capt. John Pengilly is in special charge of the mine. Two grades of ore are made at the Chandler mine, viz.: "Chandler" and "Long Lake."

A half mile beyond Ely is the mine of the Pioneer Mining Company, which was not visited, the ore being similar to that of the Chandler mine. It has commenced shipping this year, but only in comparatively small quantities.

The return trip was made quickly over an excellent road bed, and at 7 o'clock the party landed at Duluth, ready for supper and business.

Through the courtesy of Mr. M. J. Carpenter, General Manager and Vice-President of the Duluth and Iron Range Railroad, we are able to present to our readers the following interesting table, showing the amount of ore taken out of the mines in the Vermilion Range since its first opening. We offer this as an interesting exhibit of the manner in which some of our American iron and mining industries have been developed. It will be noted that the table covers only eight months of the year for the reason that lake navigation is closed for the remaining four months. In addition to the quantities mentioned in the table, about 55,000 tons of ore were sent forward last season by all-rail to Chicago and Joliet furnaces, and it is probable that these shipments will continue to be made.

STATEMENT OF IRON-ORE HAULED TO TWO HARBORS, MINN., FOR LAKE SHIPMENT IN GROSS TONS.

Month.	Grade.	1884.	1885.	1886.	1887.	1888.	1889.
April.	Minnesota	....	....	....	....	....	14,769
	Chandler	....	....	....	....	....	8,275
May.	Minnesota	....	17,934	25,561	32,851	26,577	81,653
	Chandler	....	....	....	....	....	50,209
June.	Minnesota	....	44,874	54,944	56,599	59,092	94,412
	Chandler	....	....	....	....	....	59,818
	Pioneer	....	....	....	....	....	366
July.	Minnesota	223	46,452	65,451	71,726	77,332	102,478
	Chandler	....	....	....	....	....	61,100
	Pioneer	....	....	....	....	....	1,750
August.	Minnesota	11,277	39,044	60,754	82,342	69,335	97,218
	Chandler	....	....	....	....	2.192	50,567
	Pioneer	....	....	....	....	....	767
Sept.	Minnesota	24,535	35,895	44,080	74,927	61,267	59,869
	Chandler	....	....	....	....	12,874	36.498
	Pioneer	....	....	....	....	....	239
Oct.	Minnesota	26,087	28,707	47,689	61,630	73,458	60,693
	Chandler	....	....	....	....	25,586	31,872
	Pioneer	....	....	....	....	....	42
Nov.	Minnesota	....	14,169	9,469	14,835	37,002	....
	Chandler	....	....	....	....	7,395	....
	Totals	62,122	227,075	307,948	394,910	452,110	....

We believe the mines producing these ores are the most northerly developed iron-mines in the United States.

At 8 P.M. a business meeting was held at the Spalding House, when the Committees on Nominations and Courtesies made their reports, which were accepted, and officers were elected to serve for the ensuing year. Papers were presented by Mr. J. C. Ford on "The Operation of Spring Lake Furnace," by W. S. Mallory on "Spirally Welded Tubes," and by E. Sjosdedt on "Magnetic Survey and the Magnetometer." These papers appear in this issue of the JOURNAL.

Messrs. Traver, Cook and McGugin then exhibited specimens of the ores used in their furnaces, in Eastern Tennessee, Eastern Pennsylvania and Southern Ohio, and after an interesting discussion the meeting adjourned. It is hoped that at future meetings the exhibition of samples of ore brought by members will be made a special feature.

EIGHTH DAY.

The morning was devoted to visiting points of interest at Duluth, and a number of the members were driven about the city by some of the citizens of the Zenith City.

After a pleasant sojourn of four days, the members of the Association departed from Duluth and crossed the bay to West Superior, Wisconsin, which they had been invited to visit by a committee of its citizens.

WEST SUPERIOR.

The plant of the West Superior Iron and Steel Company consists of a large brick pipe foundry, 360 feet long and 72 feet wide. Two pipe-pits, arranged with the ramming pits at one end and the casting pits in the other, and the drying ovens in the centre, have been constructed, and there is room for two more. Two Colliau cupolas, with an hourly capacity of 10 tons each, have been provided for, but only one is now in place. The waste heat from the cupola is utilized in producing steam from a Hazleton boiler, placed near the top of the stack.

The company contemplate the erection of an 18 x 80 feet blast-furnace plant in the future, and the foundations for the stack have been laid.

A most interesting visit was made to the coke-ovens and coal-docks of the Lehigh Coal Company. The former consists of 50 bee-hive coke-ovens, in which 48 and 72 hour coke is made, the best of which is shipped to Montana. These coke-ovens were built to utilize the fine coal or slack from the large coal-docks, which have a capacity of 400,000 tons, but they have proved so successful that the Company propose to enlarge the plant in the near future, and go largely into the business of coke making, as Pennsylvania bituminous coal can be cheaply obtained, and, if made into coke at this point, all the breakage and loss in transporting and reshipping the coke would be saved.

Superintendent Lewis stated that, taking the present price of Connellsville coke at $1.50 per ton at the ovens, and freight to Chicago at $2.75 per ton, the advantage which Chicago would have over the coke made from Pennsylvania coal brought to the head of Lake Superior by vessels is but nominal. The freight on coal from the lower lake ports to the head of Lake Superior by vessels seldom exceeds 50 cents per ton, owing to the fact that the heavy wheat and ore shipments make the balance of trade eastward.

One of the new vessels of Capt. Dougall's design, "102," had just been docked, and was discharging her cargo of coal. The party boarded the vessel and watched the rapidity with which the large power-scoops removed the coal from the hold and deposited it on the dock, and also inspected the cabins built for the accommodation of the crew.

After accepting the hospitality of the citizens of West Superior, at the new hotel, the party boarded their special car for Ashland, where dinner was served, and then proceeded to Hurley, Wis.

NINTH DAY.

GOGEBIC IRON RANGE.

After an early breakfast, tendered by the Metropolitan Iron and Land Company, at the Burton House, Hurley, Wis., the party visited the Norrie mine, near Ironwood, Mich., across the Montreal River from Hurley, Wis., where they were met by Captains Curry and Day, Mr. Norrie, Mr. Barrows and others. About 500,000 tons of ore had been shipped from the eleven shafts now in use during

1889, and before the close of the season the mine will reach an output in excess of 600,000 tons. All the work is carried on in underground operations, and where some large bodies of ore have been taken out, the ground has caved in, producing noticeable valleys.

The Norrie mine has achieved the honor of producing more iron-ore in the last year than any single operation in the United States except the Cornwall ore-hills of Pennsylvania. Its workings now exceed 500 feet in depth from the surface, but most of the ore is obtained from the 225- and 375-feet levels. A series of analyses of 125,000 tons of Norrie ore, shipped this year to lower lake ports, showed the following average composition (dried at 212 degrees):

ANALYSES OF NORRIE ORE.

Iron,	64.03
Phosphorus,	0.0428
Silica,	3.5 to 4.0

The company are obtaining ore from a shaft which is expected to develop a continuation of the large body of ore which made the adjoining Aurora mine so notable.

The Aurora mine was next visited, and the great open pit from which the ore was at first mined was inspected. The mine is now worked chiefly underground. It has shipped this season, up to September 25th, about 160,000 tons of ore, previous shipments having amounted since its opening in 1885 to 437,991 tons.

The next stop was made at the Colby mine, near Bessemer, Mich. This mine was operated for the last three years by Messrs. Pickands, Mather & Company, of Cleveland, under a lease, and nearly 1,000,000 tons of ore were obtained in that time. It is at present worked by the Colby syndicate, and managed by Captain Dickerson. Ore has probably been more cheaply won from this mine than from any other on the Gogebic range. The Colby ore contains from 2 to 4 per cent. of manganese, and the iron and manganese contents together average 60 per cent. when dried at 212 degrees.

Owing to the desire to visit the Chapin mine, and on account of the stormy weather, courtesies offered by other Gogebic mines could not be accepted; our readers will, however, find a description of the mines of the Gogebic range in the JOURNAL, Vol. VII., pages 155 to 165, and 226 to 228.

The trip from Ashland to Hurley and from Hurley through the Gogebic range was made by a special train, courteously supplied by the Milwaukee, Lake Shore and Western Railroad, which also carried the party to Watersmeet, where lunch was served, the car transferred to the Chicago and Northwestern Railroad, and the journey continued to Iron Mountain, Mich., to inspect the famous Chapin mine.

MENOMINEE IRON RANGE.

A number of the officers of the Chapin Mining Company met the party at the Iron Mountain Station, and acted as guides. A unique feature of the plant is the fact that all the machinery is run by compressed air, which is brought in 24-inch wrought-iron pipes from the hydraulic plant, consisting of four Victor turbines, at Quinnesec Falls, on the Menominee River, distant about 3 miles. The compressed air operates two plants of hoisting-engines, which are used in operating four shafts, with engines having 30-inch cylinders and 5 feet stroke.

The ore is brought up from the main shaft, now 375 feet deep, by a vertical hoist, in iron box-cars holding about one ton, to a platform which extends over the railroad tracks. On arriving at the top, the cars are attached to an endless chain conveyor, and drawn to an iron cradle at the end of the platform, made of two large rings, one at each end, connected by four riveted cross-pieces, two of which form tracks for the car, and the others a tolerably close fit for the top of the car; the rings rest on four wheels, two of which are on each side of the platform. As soon as the car runs on the dumping-frame, the centre of gravity which is near the top of the car causes it to commence to tilt, and the wheels supporting the frame accelerate the movement. The car is turned completely over, discharging its load into a pocket, and yet cannot fall out of the cradle; after being emptied it assumes an upright position, and is returned to the hoist by another track.

The water is taken from the mine by two Cornish pumps, lifting 1200 gallons per minute a distance of 600 feet, and are operated by two Corliss engines, 24 x 48 inches, so geared that the pumps work alternately. Boilers are at hand to supply steam in case of any accident to the compressed air system.

"The ore is mined from three separate lenticular deposits, having a pitch of about 30 degrees. The largest of these bodies has a horizontal length of 2500 feet, and a maximum width of 130 feet in the middle, from which it gradually narrows to pointed ends. To the east of this is another lens, which, in the sixth level, shows a length of 550 feet, and a maximum width of 100 feet. Farther east of this, in the belt of Jasper, the third ore lens occurs, and has a pretty regular length of 100 feet, and averages 20 feet in width. The mine is at present worked on the 'filling system.' The ore is a soft blue hematite, containing about 63 per cent. of iron and 0.07 per cent. of phosphorus."*

The mine was first opened in 1880, and the shipments since then have been as follows:

SHIPMENTS OF IRON-ORE FROM THE CHAPIN MINE.

	Tons.
1880,	34,556
1881,	134,521
1882,	247,506
1883,	265,830
1884,	290,972
1885,	157,455
1886,	198,871
1887,	336,128
1888,	272,278
Total,	1,938,117

Returning to Milwaukee the party disbanded, gratified to have formed pleasant acquaintances or cemented former friendships, enthused with the prosperity, energy and growth of the Northern cities, surprised with the magnitude of the commerce of the great lakes and its possibilities, and overwhelmed at the extent and importance of our Lake Superior mining interests as exhibited by visits to six of the great ore producers.

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THE *Iron Age* gave a very full and detailed description of the late meeting of the United States Association of Charcoal Iron Workers, and liberal abstracts of papers presented, Mr. Geo. W. Cope, associate editor, having given the matter personal attention.

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* *Vide Transactions American Institute of Mining Engineers*, vol. xvi., page 119. "The Chapin Iron-Mine, Lake Superior." By Per Lärssen.

Possibilities of Iron Manufacture in Canada.

BY JOHN BIRKINBINE, *Philadelphia, Pa.*

THE unsatisfactory results which have followed some of the attempts to produce and manufacture iron in the Dominion of Canada, and the failure of capitalists to take advantage of the bonus offered by parliament, have combined to encourage a degree of distrust in Canadian ventures which seems scarcely warranted by existing conditions.

In a paper presented by Mr. J. H. Bartlett, of Montreal, at the Halifax meeting of the American Institute of Mining Engineers, the various attempts to manufacture iron in Canada were reviewed, and the possibility of achieving success strongly presented. Mr. Bartlett justly claims that much of the discredit which has come upon investments in the production or manufacture of iron in the Dominion is due to the facility with which money was placed in so-called "improved processes," heralded as short cuts to metallurgical success. He also asserts that "the only attempt ever made to manufacture coke pig-iron and refined bar-iron has proved the possibility of so doing."

The small output of Canadian pig-iron, which has been mostly produced from bog-ores with charcoal as fuel, does not give promise of extension, for although these ores are abundant, they are lean and hydrated, requiring the mining of large quantities of ore and the rapid denudation of convenient timber on account of the consumption of ore and charcoal per ton of product. The future of the Canadian iron industry would appear to be dependent upon the magnetic and red hematite ores more than upon the leaner bog-ores, although the latter may form an important factor in mixtures. The abundance of timber promises a supply of charcoal for an industry of considerable dimensions, but wood is constantly appreciating in value for other purposes, and although there is a large field for the manufacture of iron with charcoal, the bulk of the iron produced will most probably be smelted with mineral fuel. Coal is found in the eastern provinces and also in the western section of the Dominion. There is no apparent supply of domestic mineral fuel within 700 miles of Ottawa, the capital of the Dominion.

A critical examination of a number of iron-ore deposits convenient to Ottawa, encouraged the presentation of a discussion upon the possibilities for producing pig-iron offered by the capital or its vicinity, as a basis for determining the practicabilities offered by the Dominion for iron production and manufacture. At the outset it may be noted that within 6 miles of the parliament buildings, portions of a blast-furnace are now standing, the plant having been constructed to smelt the local magnetites with charcoal, and within 11 miles there are the ruins of a forge and charcoal kilns, part of a plant where blooms were produced from ore by the direct or catalan process. Neither of these have been active in late years.

In the production of iron the first *desideratum* is the ore supply, and omitting further notice of the bog-ore deposits in Quebec or the large exploitations which have attracted attention and capital in the vicinity of Hastings, Ontario, attention will be directed to some deposits which are more directly tributary to Ottawa and from which various mixtures could be made. Some of these were mentioned in a paper by Mr. Fred. P. Dewey,* Curator of the National Museum, at Washington, and all of them are referred to in Prof. Harrington's monograph upon the Economic Minerals of the Dominion of Canada.

These ore-deposits which have been personally examined are:

A. In the province of Quebec at Hull, 6 miles, and at the Haycock location, 11 miles north of Ottawa. At Hull mining has been prosecuted to a considerable extent and large quantities of ore removed, some of which was smelted in the blast-furnace above referred to prior to its partial destruction by fire, but most of it was shipped to the United States prior to the assessment of the customs duty of 75 cents per ton. This ore was carried by rail to the St. Lawrence River on Lake Ontario for 50 cents per ton, and from the Canadian ports to Cleveland the freight was 75 cents per ton. A royalty of $1.00 per ton was also paid to the owners.

At the Haycock location and at adjacent properties, the exposure is such as to offer impressive surface indications, but although some of the mineral was worked into blooms in the forge mentioned, the operations were not sufficiently extensive to develop the properties or to prove their commercial value. This ore is mostly specular, and may develop into an important deposit.

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* *Vide Transactions American Institute Mining Engineers*, vol. xii., page 192.

The following analyses were taken from the Canadian Geological Survey:

ANALYSES OF HAYCOCK AND HULL ORES.

	Haycock.		Hull Red Ore.	Hull Black Ore.
	1	2	3	4
Ferric oxide,	88.08	85.45	66.20	73.90
Ferrous oxide,	6.86	5.24	17.78	
Manganous oxide,	0.24	0.15	trace.	none.
Alumina,	......	......	......	0.61
Lime,	0.55	0.41	1.85	......
Magnesia,	0.13	0.17	0.18	1.88
Phosphoric acid,	0.16	0.13	......	......
Phosphorus,	......	......	0.015	0.027
Sulphur,	0.03	0.07	0.28	0.085
Silica,	......	......	11.11	20.27
Titanic acid,	3.17	2.12	none.	none
Carbon,	0.35	0.28	......	......
Carbonic acid,	......	......	1.17	......
Graphite,	......	......	0.71	......
Water,	......	......	......	3.27
Insoluble,	0.26	5.77	......	......
	99.83	99.79	99.295	100.042
Iron,	66.98	63.88	60.17	53.51

1 and 2 by Prof. E. J. Chapman. 3 and 4 by Dr. J. S. Hunt.

B. The Bristol mines in Pontiac County, province of Quebec, are connected by railroad with Ottawa, 35 miles distant, and present very favorable evidences of a deposit of magnitude from which over 10,000 tons of ore have been won. Some 4000 tons of this ore were shipped to and smelted in the Charlotte furnace in New York. The ore is a rich, dense magnetite, unusually low in phosphorus, but carrying sulphur in such quantity as to require roasting, for which the property is admirably equipped. There are now in place two Taylor-Langdon roasters, and one Westman kiln, modified by Mr. Ernst Sjosdedt, resembling in many points what is known as the Davis-Colby kiln. These kilns are operated by gas generated in Langdon producers. The mine has been opened to a depth of 150 feet, with drifts along the strike of 150 feet and across the vein of 50feet in one place and 30 feet and 60 feet in length in another locality, while test-pits and magnetic surveys indicate a deposit of considerable magnitude. The following analyses show the composition of this ore, both raw and calcined :

ANALYSES OF BRISTOL ORES.

	Dry.			Roasted.			
	A.	B.	C.	D.	E.	F.	G.
Iron,	58.37	62.15	61.987	62.5	62.525	62.87	63.24
Sulphur,	1.46	0.97	2.406	0.521	1.1673	2.221	1.08
Phosphorus,	trace.	.0075	.006	.004	......	0.014	......
Silica,	11.45	8.52	7.32	......	......	......	......
Lime,	3.91	......	......	......	......	......	......

A. Geological Survey of Canada.
B. R. H. Richards, Boston.
C. Booth, Garrett & Blair.
D. Lackawanna Iron and Coal Co.
E. McGill, Ottawa.
F, G. Troy Iron and Steel Co.

Later experiments, however, with the roasters show, according to Mr. McGill's analyses, that the sulphur was reduced to 0.279.

C. In Lanark and Renfrew counties, Ontario, 30 miles west of Ottawa, there are some favorable exposures of hematite and magnetic ores; samples taken from exploration shafts or outcroppings analyzed as follows:

	Magnetite.	Hematite.
Iron,	65.31	66.00
Phosphorus,	0.017	0.06

The location of these ores, while convenient to Ottawa, is such as to facilitate their smelting with charcoal, for they occur in a well-timbered district, in which hard woods predominate.

D. Still further west in Ontario, on the line of the Kingston and Pembroke Railroad, are deposits of magnetite, which have been wrought considerably; such as those at Calabogie Lake and at Wilbur mine. The latter was operated by the Bethlehem Iron Company of Pennsylvania, and considerable ore was shipped to the furnaces of that company at Bethlehem. These ores could also be made accessible to a smelting plant at Ottawa, and lately considerable exploring work has been done in the vicinity of these operations by parties from the United States.

Analyses of some of these ores are presented by Mr. Dewey in the paper above referred to; they show from 57 to 65 per cent. of iron, with phosphorus generally below the Bessemer limit, and none of the determinations give over 4 per cent. of sulphur. Titanium, when present at all, is, according to the analyses, not over 1 per cent.

There are some hematite-ores in the vicinity of Ottawa, but most of the development has been in the deposits of magnetite, and those nearest the city are generally sulphurous; a characteristic which should not necessarily condemn them, in view of the facts that over 1,000,000 tons of sulphurous magnetites are annually smelted in the United States, and that some of the American furnaces which have been most successful financially have used entirely or largely such ores.

Blast-furnace practice has demonstrated that it is difficult to produce good foundry grades of pig-iron with dense magnetites, particularly if they carry considerable sulphur; but modern plants, improved methods and chemical research have done much to remove these troubles, and it is not prophesy to state that with a well-equipped and properly managed plant, using thoroughly roasted magnetites instead of ore partially calcined, satisfactory work in this particular can be obtained*.

There seems, therefore, ample ground for relying upon the possibility of assembling a satisfactory supply of ores at or near Ottawa for the maintenance of a smelting-plant.

The limestone which abounds in the vicinity of Ottawa, and which forms the barrier through which the Ottawa River breaks in creating the Chaudiere Falls, furnishes ample flux. This stone is largely magnesian, but officers of the Geological Survey state that it can be obtained as nearly pure carbonate of lime or with varying proportions of lime or magnesia, and the flux can therefore be readily supplied.

The key to the problem would appear to be that of fuel. The Canadian customs protect its domestic bituminous mines by imposing a duty of 60 cents per ton on bituminous coal, or coke made from it, but anthracite coal is admitted free of duty. Notwithstanding the tariff levied on foreign bituminous coal, the supply for the

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* *Vide* JOURNAL, vol. viii., p. 21.

Province of Ontario comes principally from the United States. Last year over 2,000,000 tons of anthracite coal from Pennsylvania were consumed in the Dominion, and in addition 1,250,000 tons of bituminous coal from the United States paid a duty of 60 cents per ton.

The consumption of anthracite is not surprising when we remember that Scranton, the centre of the Lackawanna coal district of Pennsylvania, is no further from Ottawa, in a direct line, than it is from Rouse's Point, N. Y.; Portsmouth, N. H., or Cleveland, Ohio.

Independently of the customs duty, Ottawa is as favorably located for obtaining a supply of Connellsville coke, as the blast-furnaces on Lake Champlain, or those at Chicago; and under favorable railroad rates the cost of coke furnished in large quantities from the Connellsville district at Ottawa should be practically the cost at Chicago plus the duty of 60 cents per ton. The distances from Ottawa to Connellsville, Pa., and to the boundary of the Province of New Brunswick, are practically equal.

If, however, coke made from coal obtained in some of the northern counties of Pennsylvania is brought to Ottawa, there would be a difference in distance of about 100 miles in favor of Ottawa, as compared with Chicago, to offset the duty.

Whether a supply of coke would come from the Connellsville district, or from some of the more northern Pennsylvania plants which now produce very satisfactory coke for iron smelting, or whether it would be brought from the eastern provinces of the Dominion, would be determined by a full consideration of the subject from a commercial basis when contracts were to be let; but to place the problem on a perfectly equitable footing, we may take the price of coke at Connellsville at $1.50 per ton; add transportation equivalent to the freight from Connellsville to Chicago, $2.75 per ton, add for duty 60 cents per ton, making a total of $4.85 per ton. Allow for less favorable freight rates to Ottawa than given to Chicago, we may add 25 cents per ton; making coke at Ottawa cost $5.10. Therefore, if Connellsville coke costs this amount at Ottawa, a comparison can be made with the cost of that produced in the eastern provinces, or obtained from points in Pennsylvania 100 miles nearer Ottawa than Connellsville.

Anthracite coal can now be delivered at the furnaces on Lake Champlain for $4.25 per gross ton, and an allowance of $5.00 per ton at Ottawa would therefore appear to be sufficient. Whether a mixture of anthracite coal and coke would be most advantageous, or what that mixture would be, can only be decided upon actual contract quotations; but from the above figures, an allowance of $6.50 for the fuel to produce a ton of pig-iron at Ottawa would appear to be conservative.

To obtain an estimate of the cost of material used in the production of the metal, we may assume that the ore from the Bristol mines is used, as the development of this property, its roasting equipment and the indications of a large deposit existing, offer the most satisfactory conditions for immediate utilization, while its distance from Ottawa (35 miles) is such as will embrace other ore-deposits, which have been referred to, some of which will not require roasting to eliminate sulphur, and others may be used as mixtures. To allow liberally, the cost may be taken of the

	Per ton.
Raw ore at the mines at	$1.40
Add roasting and loss,	.60
Freight to Ottawa,	.55
Cost of 1 ton of ore,	$2.55

As this roasted ore will yield 60 per cent. of iron, or more, the cost of ore for a ton of pig-iron will be: 1⅔ tons at $2.55 equals $4.25. The convenience of fluxing material will make this item small, and an allowance of 50 cents per ton of iron made should be ample. The materials for producing a ton of pig-iron may therefore be summarized as:

Fuel,	$6.50	
Ore,	4.25	
Flux,	.50	
		$11.25
To which may be added for labor, repairs, office expenses, supplies, incidentals, depreciation, etc., say.		2.75
Making a ton of pig-iron cost		$14.00

A figure possibly above what practical operation may demonstrate as the actual outlay, but still sufficiently low to encourage operations which will displace at least a part of the 50,000 tons of pig-iron annually imported into the Dominion, or furnish material which may be utilized to produce a portion of the 250,000 tons of manufactured cast- and wrought-iron which enter Canada each year.

That a possible market for the product of a number of furnaces exists in the Dominion needs no exemplification to those who are at all familiar with its territory and its people. But the question naturally arises, can pig-iron be produced in the Dominion to compete with foreign metal?

In this estimate the locality selected for the smelting of the ores is near the vicinity of Ottawa. There may be other points apparently even more favorably situated, and in that case comparative figures can be readily made. Similarly the ore from the Bristol mines is used as a basis for estimating, because of its convenience to Ottawa, its condition for immediate utilization and the known composition of its product. If ores from other localities are preferable, or if they are to be used as mixtures, proper allowances can be made. We may therefore use the figures of estimated cost herein given as a basis for determining what chances Canadian pig-iron has in competition with foreign iron.

The Canadian duty is now $4.00 per net ton on pig-iron—the estimated cost above is per gross ton. In addition, the government offers a bonus of $1.00 per net ton on all pig-iron made in Canada from Canadian ores, therefore the domestic metal would be protected, at least until the expiration of the bounty period, to the extent of $5.00 per net ton, or about $5.60 per gross ton.

If now, pig-iron made at Ottawa costs $14.00 per ton, foreign metal would have to be delivered there at $8.40 per ton to meet this cost. But an allowance for profit must be made; including this, as well as the percentage of loss from bad debts, and also adding liberally for possible discrepancies in the estimate, say $2.60, the domestic product could meet foreign iron delivered at Ottawa at $11.00 per ton. As the iron is shipped away from Ottawa, freights must be added, but there still seems to be ample margin to encourage the production of domestic pig-iron in Canada.

The estimates offered are for the production of pig-iron, using anthracite coal, coke, or a mixture of these two fuels, but the subject should not be dismissed without considering the possibility of employing charcoal as fuel, and considerable discussion has, from time to time, been had upon the utilization of the enormous waste from the mills at Ottawa, by converting it into charcoal. The slabs and larger refuse could be charred in kilns, but most of the timber now used in the mills is of a character producing charcoal of inferior quality for blast-furnace use. Improvements in manufacture are also utilizing much of the waste for special products, which reduce the chances of a permanent supply for this purpose.

There seems to be more encouragement to convert the saw-mill refuse and saw-dust into gaseous fuel, as in Sweden, and use it for manufacturing iron and other metallurgical purposes. Gas producers for this purpose would have to be equipped with condensers, for the refuse material supplied to the producers would carry 40 per cent. or more of water.

If pig-iron is produced in the vicinity of Ottawa, there would seem to be good encouragement for investigating the economical employment of this waste material, and also the possible utilization of some of the water-power available in the vicinity.

As noted before, the production of charcoal pig-iron apparently offers greater advantages at some of the localities where the ores and hard-wood timber are contiguous. The charcoal required for smelting a ton of pig-iron would probably cost from $7.00 to $8.00 at Ottawa, from $1.00 to $2.00 in excess of the cost at the other points indicated. As this charcoal-iron would be used for special purposes, it should command a corresponding price in the market.

Apatite.

IN many instances where the proportion of phosphorus in iron-ores is large, it is present as apatite or phosphate of lime. This is particularly the case in some magnetites and altered magnetites, where the apatite crystals are intimately associated with the ore.

In considering the features of iron-ore concentration attention has been directed to the possibility of utilizing the apatite which would be separated from the ore, and a late visit to the phosphate-mines in the Province of Quebec, Canada, offered opportunities for collecting data concerning apatite, due to the courtesy of Mr. J. Obalski, Government Mining Engineer for the Province of Quebec, which we offer to our readers.

Dana states that apatite is so called because it deceived the older mineralogists; it is often, on account of its color, called "asparagus stone," but while usually green or bluish green, it is often violet, blue, sometimes white, yellow, gray, red or brown, none of the latter colors being bright.

We obtained yellow crystals among the martite-ore of the Cerro de Mercado at Durango, Mexico; reddish brown crystals in Lake Champlain magnetites, and green crystals from the Canadian apatite-mines.

Mr. Obalski states that "the use of phosphate of lime for agricultural purposes can scarcely be traced back further than the year 1840, and since then rich phosphates (apatites) have been found in Norway, in Spain, in Canada, and equally rich phosphorites have been discovered in Russia, in the south of France, in Germany (Nassau), in the West Indies (Islands of Havassa and Curacoa), in certain islands of the Pacific, and poorer phosphates—(often coprolites), in England, in the north of France, in Germany, in South Carolina (U. S.), etc. The latter (coprolites) may be used when pulverized in their natural state, as they can be easily assimilated by plants, while the apatites, after pulverization, must be treated by sulphuric acid, resulting in a product called superphosphate."

To give an idea of the commercial value of this product it will be sufficient to state that England imports yearly 300,000 tons.

"Commercial apatite is at present obtained principally from Norway, near the coast, in central Spain and in Canada, in the neighborhood of Ottawa, Kingston and Perth; the Canadian apatites are generally of a greenish tint, but sometimes red; the Norwegian and Spanish are nearly white in color. In richness (that is, in the proportion of pure apatite contained in the mineral) Canada leads, Norway ranking second, and Spain third. All of the commercial apatite contains some fluor-spar, and none is obtained perfectly pure." Some of the crystals which are found in the Canadian deposits show by analysis as much as 93 per cent. of phosphate of lime. Its chief use is for producing superphosphates for agriculture, and it is generally sold on a unit basis; thus the Canadian shipments range from 75 to 85 per cent. of pure apatite, the prices varying according to the market, but on the standard basis a mineral yielding 75 per cent. of pure apatite would command 20 cents per unit, or $15.00 per gross ton, and this rate per unit continues up until 80 per cent. mineral, when 25 cents a unit, or $20.00 per ton is paid. For any excess over 80 per cent. there is an extra allowance of ⅕th of a penny, or say 4 mills per unit. Thus an 85 per cent. mineral which would command 25 cents plus 2 cents, equals 27 cents per unit, or $22.95 per ton. These prices are for a gross ton on the dock at Liverpool, England, and are now lower than are usually obtained.

The presence of oxide of iron above 1 per cent. is considered disadvantageous, as in the treatment with sulphuric acid, to convert the practically insoluble phosphate into a soluble compound, the iron exerts a retarding influence. Apatite is a chemical compound of one part of phosphoric acid and three parts of lime. By treatment with sulphuric acid, two parts of lime unite with the sulphuric acid, making an insoluble sulphate of lime, while the remaining part of lime is combined with the phosphoric acid, and forms the phosphate of lime which is soluble, the province of the sulphate of lime being merely that of a conveyor for the soluble phosphate.

Mr. Obalski prepared the following comparative statement of the percentage of apatite in the different phosphates:

	Per cent.
Norway,	82 to 84
Russia,	30 " 60
England,	57
France,	35 " 45
France,	68 " 78
Germany,	31 " 42
Germany,	38 " 76
Spain,	45 " 85
West Indies,	69 " 88
Pacific Ocean,	73
United States (South Carolina),	55 " 88
Canada,	75 " 85

He also presents the following analyses of cargoes of Canadian apatite exported to England:

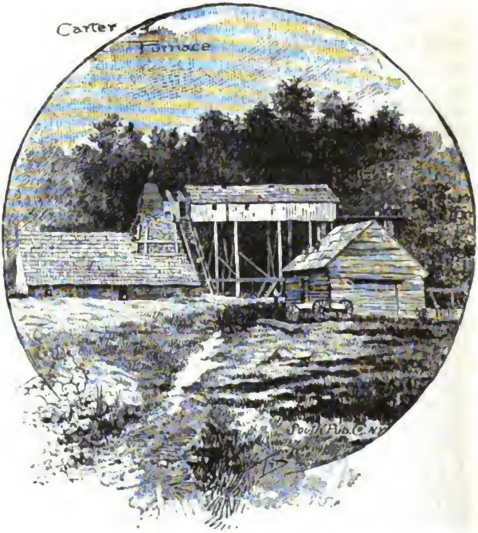
ANALYSES OF CANADIAN APATITE.

	Per cent.	Per cent.
Moisture,	0.10	0.10
Water,	0.50	0.15
Phosphoric acid,	37.60	36.65
Lime,	51.52	50.96
Oxide of iron and alumina,	1.50	1.40
Magnesia and not determined,	5.18	4.09
Carbonic acid,	0.60	1.50
Insoluble,	3.00	5.15
Total,	100.00	100.00
Equivalent to Tribasic phosphate of lime,	82.10	80.01
Carbonate of lime,	1.36	3.40

If the apatite is thoroughly separated from iron-ore it would undoubtedly be a commercial product, and it is questionable if a small amount of magnetic oxide of iron would materially decrease its value, for the objection to iron is that it retards producing a soluble phosphate, and magnetic oxide iron is but feebly touched by sulphuric acid; another point favoring the utilization of apatite separated from iron-ore would be the fact that, occurring in crystals, it would be of high grade. THE EDITOR.

An Old Blast-Furnace.

THE pioneers of our iron industry, the cold-blast charcoal furnaces are rapidly passsing away, having outlived their usefulness; they are either entirely razed or give place to structures more modern in design and equipment. We therefore take pleasure in reproducing for record an illustration kindly loaned by the Knoxville Car Wheel Company, Knoxville, Tenn. The cut shows the Carter furnace, which, while not numbered among the older American blast-furnaces, represents the prevailing primitive construction of the cold-blast charcoal blast-furnaces, and shows by comparison the strides in iron metallurgy made by more modern plants. Concerning the furnace illustrated, the Knoxville Car Wheel Company say:



"Carter Furnace is located in Carter County, Tennessee, and was built in 1844. It was always run as a cold-blast furnace, the blast being furnished by a pair of wooden tubs and a water-wheel. All the fixtures were in the primitive character of that date. The product never exceeded six tons per day; but the pig-iron was pronounced equal to any in the country. Wheels made of this iron exclusively have made their sixteen years mileage on the East Tennessee, Virginia and Georgia Railroad. The furnace was dismantled after forty years' service. The same ores are now being used in our furnace."

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THE continuation of the description of the Lake Champlain iron-ore district from JOURNAL, page 218, is deferred to give place to the papers and proceedings of the annual meeting of the Association. We expect to continue this description, and also the articles on concentration of iron-ores, in future issues.

Unreduced Ore Passing Through a Blast-Furnace.

By EDGAR S. COOK, *of the Warwick Iron Company, Pottstown, Pa.*

[Prior to the meeting Mr. Cook exhibited to the Secretary an interesting suite of samples of partly-reduced iron-ore which had been taken from the tuyeres of the Warwick furnace, and he was requested to exhibit the same to the Association, giving his views of the conditions under which they had been produced. Some of the pieces of ore were only partially deoxidized on the surface, and some were incased in a covering of what appeared to be wrought-iron.]

MR. COOK stated that "in two of the specimens the ore was from the Republic mine in the Lake Superior district, and when the pieces were broken they showed the distinct characteristics of this ore, although they had passed through the furnace. The furnace had been running on one lining for about three and a half years, making 108,000 tons of iron in that time. For the year ending on February 1st last, the furnace had been running very well, making from 650 to 710 tons of iron per week, although it is but a small furnace, 15½ x 55½ feet. During February the furnace began to work irregularly, and the yield fell off to 550 and 600 tons per week. About March 1st " there was a regular circus." During the progress of the blast the brick-work of the bosh had melted away. This had been replaced, in part, by carbonaceous or graphitic material, together with some lime and finely-divided ore. Owing to the large product of the furnace for the preceding months, at the time just referred to this filling loosened and slipped down *en masse* into the crucible. The temperature of the crucible was so reduced by this fall that it was with difficulty that the tuyeres were kept open. The iron-notch and cinder-notch became closed. Several tuyeres were closed at the nose by plugs of the spongy iron, followed by the partial fusion of unreduced ore, or, as we term it, fine ore dirt. The other tuyeres were kept open, and the slag made was discharged from the furnace through the tuyere slagging-valves attached to the belly-pipes. These valves are operated by air-cylinders, and are opened and closed with the engine running, and the slag can be discharged without any risk or loss of time. After about twenty-four hours of close attention and hard work, the furnace was again in fair working order. An examination showed that the brickwork on the west side of the furnace about the top of the bosh was only 2 to 3 inches thick, while on the east side it was 9 to 10 inches. This was determined by drilling holes at intervals through the furnace walls. In order to fill up and restore the bosh to something approximating suitable proportions, it was decided to run the furnace on silver-gray iron in hopes that a graphitic bosh could be formed. It was while this effort was being made that the samples of unreduced ore were obtained from the tuyeres on the east side. We noticed that the tuyeres on the west side worked much better and brighter than those on the east side. The temperature was experimentally determined by driving bars of wrought-iron into the centre of the furnace through the plug-holes of the several tuyeres. On the west side the bars became white-hot and melted off before they could be drawn out, while on the east side similar bars were bright red at the points, but only dull red for the greater part of their length. About the same time the tuyeres on the east side were rapidly cut, exploding with reports similar to pistol shots. As these tuyeres were removed, the stock in front of them was shovelled out and preserved. It was from this stock that the specimens of unreduced ore were selected. At this time the stock was passing through the furnace in about sixteen to eighteen hours, and the iron made was chiefly No. 1. The slag was uniform and hot, the furnace was working fairly regular, but not with the usual fuel economy or average yield of iron. Owing to the shape of the furnace being oblong instead of circular, it was supposed that a much larger volume of gas ascended on the west side than on the east side. The gas currents thus established thoroughly reduced the ore on that side, but were deficient in quantity on the east side, and thus the ore on this side descended without being properly acted upon, and reached the tuyeres and crucible unreduced. The presence of unreduced ore naturally made that side of the furnace work cold, and this again facilitated still further arrivals of unreduced ore in the crucible. The frequent loss of tuyeres was due to the formation of pockets under the tuyeres, which filled with iron as it was melted, and this iron, coming into contact with the bronze of the tuyeres, produced the explosions. In order to correct this condition of affairs, a long tuyere was placed on the west side, projecting 20 inches or more beyond the tuyere breast, and small nozzles of 3 inches in diameter instead of 5 inches were placed on the east-side tuyeres. This seemed to answer a good purpose, and it was not long before the east side was heated up. We then ceased losing tuyeres, and the temperature of the crucible seemed to be uniform on all sides. At all events, no more unreduced ore was discovered at any of the tuyeres. The effort to restore the bosh was found to be costly, calling for a largely increased consumption of fuel, which the condition of the iron market would not warrant, so we decided to work up our ore stocks and blow out for repairs. During the last six or eight weeks of the blast an increased volume of air was blown in order to keep the furnace working regularly with its enlarged bosh area, so that the furnace was emptied in from twelve to fourteen hours. Even when the stock was exposed only twelve hours I was not able to discover any unreduced ore at the tuyeres, so I am satisfied that the finding of ore only partially reduced some weeks previous was not due to rapid driving, but solely to the imperfect distribution of the reducing gases, and that these currents were influenced in a measure by the shape of the furnace."

A discussion followed in which a number of the members participated, and in which the details of the occurrence were considered with reference to air-pressure, method of charging, nature of stoves used, etc. Mr. Cook stated that this phenomenon is not so likely to occur from the cause named when coke alone is used for fuel. He used one-fourth coke and three-fourths anthracite, and anthracite-furnace practice was much more difficult than coke.

The Outlook.

THE present outlook for the American iron and steel trades is in many ways encouraging, but the prospect is not without some elements of danger. During the entire year, 1889, the volume of business has been great, but until lately prices have been so low that the profits were unsatisfactory. An increased demand has improved the market, and a general advance in quotations has been the result. Up to present writing the advance in this country is no greater than that to be expected, as the natural fluctuations in value, due to a slow or brisk demand for the product of furnaces and mills; but in England and in parts of continental Europe the prices indicated an unhealthy advance, or, to use an American phrase, "they were booming." We trust this tendency will not extend to this country, for the evil results of a reaction will more than counter-balance any benefit resulting from a "boom."

The iron and steel business is at its healthiest tone when manufactories, well located and well managed, earn a fair profit on the capital employed, and when materials command moderate prices. A "boom" brings labor strikes and high transportation rates, which continue longer than the advance prices received for the manufactured articles. Apparently excessive profits encourage the operation of plants which under ordinary conditions of trade are unable to continue in activity, then when prices decline and these plants can no longer compete, the resultant financial disturbances bring unjust discredit upon the business. That business is most permanent and prosperous which pays a moderate but practically uniform interest on the capital employed, and many of the failures of iron and steel producers and managers are directly traceable to the influences of "booms" or the reactions which follow them.

THE EDITOR.

Moisture in the Blast.

BY SAMUEL D. MILLS, *St. Ignace, Michigan.*

THE following incident led to some investigations which may be interesting to the readers of the JOURNAL:

One day in December of last year (1888) a slight leakage occurred in one of the hot-blast stoves connected with the Martel furnace at St. Ignace, Michigan, and on going on top to examine the leak on a very cold morning, I was surprised to see a small icicle hanging from the bracket which supports one end of the gallery near the top of the stove, and for the time I was puzzled at finding that the icicle was formed by a small stream, or rather oozing of water from the leak which was under the manhole plate nearest to the bracket; there was also a tiny stream coming from another leak, and running down the side of the stove for nearly 25 feet before it was dried up by the heat of the stove casing, aided by the dry frosty air. It seemed at first sight rather a conundrum how a stream of water could leak out of a stove which was then supplying about 1200° F. heat to the blast. I did not at first think of the difference in temperature between the outside air and that within the engine-room as being likely to afford an explanation of the mystery, but questioned whether the moisture from the ore (some of which was very damp) being carried with the gases into the stoves could have anything to do with it. Finding, however, that the other stove in which the gas was then burning showed no sign of moisture, I saw that it was useless to look in that direction for the cause. After the leaks were repaired I went down to the engine-room, and there noticed (what I had often seen before, without thinking what it meant) that the water pipes from the pumps (which are in the same building), as well as all the cold parts of the machinery, and even the beams of the roof, were covered with dew, showing that the atmosphere there was so charged with moisture that it was at the point of saturation, or "dew-point," in all the cooler parts of the building. As the "dew-point" depends upon the temperature, the next step was to ascertain the temperature in different parts of the building, and especially near the valves of the blowing-cylinder. The temperature out of doors was at the time about 10° F., weather, clear and bright. In the engine-room it was found that the floor-temperature with the doors closed was about 55° F., 4 feet above the floor, 60° to 68° F., and on top of the blowing-cylinder nearly 80° F. There was no dew on the valve-seats, but the roof beams, 9 feet above the cylinder-head, were dripping, the temperature there being reduced to about 75° F. by the proximity of the bottom of the iron water-tank which forms the roof of the engine-house. It was evident that the air was at its "dew-point" at about 75° F. Now the point of saturation, or the quantity of aqueous vapor contained by air is, at the various temperatures given, as follows:

	Pounds per cubic foot.
At 32° F.,	0.000331
" 40° F.,	0.000431
" 50° F.,	0.00060
" 60 F.,	0.000825
" 70 F.,	0.00112
" 75 F.,	0.00131

Therefore, with an engine delivering 225 cubic feet of air per revolution, and the temperature at which the air was saturated with moisture assumed at 75° F., we delivered into the furnace at every revolution 0.295 pounds of aqueous vapor. If the temperature of this air was reduced even to 50° F., we would effect a saving in this respect equal to about 0.17 pounds of vapor, and further, if we could have taken advantage fully of the conditions existing out of doors with the temperature at 10° F. and dry air, we would then have been sending into the furnace but 0.025 pounds instead of 0.295 pounds per revolution. If we multiply these figures by 29 (the speed at which the engine was working), we have about the relative quantities of moisture driven into the furnace per minute when the furnace is making in the neighborhood of 60 tons or over per day.

Every pound of water thus delivered into the furnace has to be decomposed at an expenditure of 6892.4 heat-units (I prefer stating this in heat-units instead of calories, as we are dealing with material ordinarily calculated in pounds and not in kilogrammes); and under the conditions existing in the neighborhood of the tuyeres in a blast-furnace, the carbon of the fuel can only be burned to carbonic oxide; thus furnishing about 4000 heat-units per pound of carbon; so that for the decomposition of each pound of aqueous vapor there is required an expenditure of 1.72 pounds of carbon. The heat which would otherwise be developed by this quantity of fuel, is to some extent, totally lost, and the rest of it transferred from a point where it would do effective service to another point higher in the stack where it is of little use, the reason being that the hydrogen of the water cannot be re-oxidized (or burned) until it has passed upwards in the furnace to a point where the *solid* carbon has ceased to have a reducing or de-oxidizing influence. Some of this hydrogen occasionally passes off unburnt, and for any that does so we have to calculate as a total loss the quantity of heat consumed in de-oxidizing it at the tuyeres, and it is stated that in some cases it has been actually detected in the act of feloniously carrying off with it a certain quantity of carbon in combination as a hydrocarbon gas. Let us now tabulate the figures at the three different temperatures above mentioned:

Temperature.	Pounds vapor in 225 cubic feet.	× 20 rev.		Pounds carbon for decomposition.	At 2⅓ tons iron per hour equals bushels of charcoal per ton.	Saving by reducing temperature bushels of charcoal.
75° F.,	0.295	= 5.90 pounds,	requiring	10.16	12.19	
50° F.,	0.125	= 2.50 "	"	4.30	5.16	7.03 per ton.
10° F.,	0.025	= 0.50 "	"	0.86	1.03	11.16 " "

The abstraction of so much heat from the zone of fusion, of course, causes the furnace to produce a harder grade of iron, and consequently necessitates the use of a larger quantity of fuel to make the desired grade, and the possibility of a further result has suggested itself. It appears probable that the most active agent in the decomposition of the vapor would be the drops of molten iron as they pass down before the tuyeres into the crucible; if this be so, then the apparent reaction would be oxidation, by the nascent oxygen, of the *silicon* in combination with the iron, the result being the withdrawal of a certain portion of the silicon and the consequent hardening of the iron. This offers an interesting subject for investigation, whether iron made when there was much moisture in the blast would prove lower in silicon than that made with a comparatively dry blast. Next comes the question what can be done in the way of improvement in this matter? Of course, in southern latitudes where the temperature is always somewhat high and the moisture less variable, we cannot look for any great change, but in the case of our northern furnaces it is different. We should take every advantage of the facilities for obtaining dry air which are offered by the cool climate. We should, if possible, take the air for our blowing engines directly and *entirely* from outside of the buildings, for even in cold, rainy weather the cool air outside will contain less actual moisture than the *apparently dry* heated air in the building. I would even suggest the construction of vertical blowing engines with somewhat higher frames and longer piston-rods to the air-cylinder; so that a floor fitted around the engine frame, about 1 foot below the lower side of the air-cylinder, would not interfere with the crosshead, and that inside the frame, and fitting loosely around the piston-rods of the air-cylinder, there should be a movable floor, so as to prevent the ascent of the moist heated air from below. The air-cylinder being thus enclosed practically in a separate room, amply ventilated from the sides, the engine-room could be kept comfort-ably warm for the engineers, and yet the engine would be supplied with the coolest air obtainable.

In conclusion, I would mention, for the benefit of those of the readers of the JOURNAL who may not be familiar with calculation respecting heat of vaporization, etc., that this forcing of aqueous vapor into the furnace must not be looked upon as equivalent to putting an equal weight of *water* into it, this being a case where the water is already vaporized. We would suffer an additional loss of 1103 heat-units per pound if *water* at 75° F. were forced into the furnace instead of aqueous vapor at the temperature which it possesses after passing with the blast through the hot-blast stoves. This also opens up another matter for consideration, namely: the value of the vapor as a conveyor of heat from the stoves to the furnace.

The subject which has attracted Mr. Mills's attention has been several times brought to the notice of our readers, and it is one which we have long believed should command more interest than is usually accorded to it by those who operate our blast-furnaces. In the JOURNAL, vol. iv., page 302, will be found a table showing the variation in the amount of moisture carried into the blast-furnace with each 1000 cubic feet of air during each of the months of the year 1836. Again, in vol. vii., page 30, we gave our readers the percentage of moisture in the blast, taken from the records of a German charcoal furnace. On page 334, vol. vii., we discuss the possibility of refrigerating the blast, so as to introduce a minimum, or, at least, a uniform quantity of aqueous vapor into the blast-furnace.

The fact that the operation of blast-furnaces is, under ordinary conditions, most favorable in cold, dry weather is generally recognized, and the possibility of reducing the fuel consumption and improving the output of the furnace by giving attention to the condition of the air which enters the blowing apparatus seems to us to offer a field worthy of more investigation than has heretofore been given. In presenting Mr. Mills's paper we trust that it may encourage a further discussion of the subject, or, at least, lead to investigation of the possible economies which would follow using blast at a uniform degree of saturation.

THE EDITOR.

Vol. 8. 1890. No. 6.

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OF THE

UNITED STATES ASSOCIATION

OF

Charcoal Iron Workers.

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— OF —

Charcoal Iron Workers.

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OF
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To meet the demand for complete volumes of the Journal, the publishers have depleted the stock of certain numbers, so that it is considered advisable to direct attention to the fact that unless additional copies of some of the issues can be obtained, but few more complete sets can be supplied at the prices named in the advertisements. The numbers which at present are scarce and for which compensation in exchanges or in money will be paid are:

Vol. I., No. 1, June, 1880.
Vol. I., No. 2, August, 1880.

The Editor.

Minutes of the Tenth Annual Meeting of the United States Association of Charcoal Iron Workers.

FIRST SESSION.

ATHENÆUM HALL, MILWAUKEE, WIS., September 17th, 1889.

THE meeting was called to order at 8 P.M., President I. M. Bean in the Chair. Mr. Bean cordially welcomed the Association on behalf of the local committee of Milwaukee, and spoke of the great advance made in the manufacture of charcoal pig-iron in recent years; the production of a blast-furnace having risen, within 25 years, from 8 to 10 tons a day to an average of 60 tons per day, and in the case of the Ashland furnace, to about 100 tons.

The report of the Secretary and Treasurer was then presented, as follows:

SECRETARY'S REPORT.

To the Board of Managers and Members of the United States Association of Charcoal Iron Workers:

GENTLEMEN:

At the date of the last report, the roll of the Association contained the names of 264 members; during the year the deaths, resignations, and those dropped on account of default of dues, numbered 24. The new members added were 16, reinstated 1, showing a loss of 7, or three per cent., and making the present membership 257.

Of these, 246 are located in 27 States, the remaining 11 being residents of 6 foreign countries.

The geographical distribution of members and associates, as given by States and countries, is exhibited in the following statement:

Pennsylvania,	59	Oregon,	3
Tennessee,	28	Virginia,	3
Michigan,	25	Kentucky,	2
New York,	24	Maine,	2
Alabama,	20	Massachusetts,	2
Ohio,	16	Minnesota,	2
Missouri,	12	Washington,	2
Connecticut,	10	Colorado,	1
New Jersey,	9	Georgia,	1
Wisconsin,	7	Iowa,	1
Illinois,	5	Texas,	1
Indiana,	4	West Virginia,	1
Delaware,	3		
Maryland,	3	Total,	246

FOREIGN MEMBERS.

Canada,	3	Hungary,	1
Sweden,	3	Prussia,	1
Austria,	2		—
England,	1	Total,	11

To illustrate the present status of the Association in comparison with the record of previous years, the annexed statement is submitted:

	YEAR ENDING.								
	Oct., 1881.	Oct., 1882.	Oct., 1883.	Oct., 1884.	Oct., 1885.	Oct., 1886.	Oct., 1887.	Oct., 1888.	Sept., 1889.
Honorary Members.....	8	8	10	11	9	9	9	9	9
Foreign Members........	6	10	12	8	10	11	8	6	5
Members..................	186	239	267	277	243	209	205	215	211
Associates.........	.....	16	51	68	55	57	50	34	32
Total....................	200	273	340	364	317	286	272	264	257

The deaths reported are:

C. Sprong, Florence, Wisconsin.
W. R. Davenport, Erie, Pa.
S. H. Witherbee, New York City, N. Y.
W. H. Barnum, Lime Rock, Conn.

The committee appointed at the last annual meeting to take action in regard to tariff legislation then pending, visited Washington and presented a protest, which has been published in the JOURNAL, vol. viii., page 125.

Owing to the death of Mr. Samuel Noble, then President of the Association, the meeting which had been arranged to be held in Alabama last year did not take place, but a formal meeting was called at New York City. (This meeting was, however, made enjoyable by the courtesy of Mr. Jos. D. Potts, a member of the Executive Committee, and Mr. T. A. Edison). Because of the fact that our meeting did not embrace excursions, the Executive Committee assessed no dues on the members who had been connected with the organization for years, and the financial statement therefore does not exhibit the usual amounts of receipts and disbursements. It is, however, important that the dues for the coming year be promptly paid so as to place the Association in funds.

I am also glad to report that the Journal Publishing Company is in satisfactory condition.

FINANCIAL STATEMENT.

Receipts and expenditures of the Treasurer of the United States Association of Charcoal Iron Workers, from October 1st, 1888, to September 1st, 1889:

To cash balance on hand October 1st, 1888,	$ 60 92

Receipts.

To amount received for dues,	345 00
To amount received from the Journal Publishing Company for advertisements and back numbers of Journal,	149 47
	$555 39

Disbursements.

By office expenses, clerical labor, postage, telegraphing, expressage and incidentals,	$240 46
By amount paid Journal Publishing Company, percentage of dues,	140 00
By stationery and incidental printing,	61 00
	$441 46
Cash balance, September 1st,	113 93
	$555 39

This does not include any compensation for the Secretary.

The following committees were appointed by the President:

On Nominations, Mr. L. Heber Smith, Chairman, J. J. Traver, J. M. Ashlock and A. E. Noble; On Courtesies, W. N. McGugin, Chairman, Edgar S. Cook, W. B. Vance and A. R. Mackintosh; To Audit the Treasurer's Accounts, Messrs. Henry Whiteley and Horace Magee.

Mr. John Birkinbine exhibited to the members some specimens of crystalline magnetic iron-ore, of exceptional purity, the iron ranging from 69.2 to 72 per cent. taken from one of the New-Bed openings of Messrs. Witherbees, Sherman & Co., at Mineville, near Port Henry, N. Y.*

Mr. Edgar S. Cook, of Pottstown, Pa., then presented a paper on "Unreduced Ore Passing Through the Furnace," and a short discussion followed.

Mr. Victor O. Strobel, of Philadelphia, then read a paper on "The Development of the Fire-Brick Hot-Blast Stove," and after a general discussion, the meeting adjourned.

[All of the papers read at the various sessions except that read by Mr. Strobel have appeared in the JOURNAL.]

SECOND SESSION.

SPALDING HOUSE.
DULUTH, MINN., September 23d, 1889.

The meeting was called to order at 8.30 P.M., President I. M. Bean in the Chair.

The Committee on Nominations reported the following suggestions for officers:

President.

W. N. McGUGIN, Ironton, O.

Vice-Presidents.

M. R. HUNT, Ashland, Wis. JOHN W. NOBLE, Anniston, Ala.
E. L. FOOTE, Sligo Furnace, Mo.

Board of Managers.

J. D. Potts, Philadelphia, Pa.; J. C. Fuller, Pine Grove Furnace, Pa.; John R. Whitney, Philadelphia, Pa.; L. Heber Smith, Joanna, Pa.; A. G. Curtin, Jr., Roland, Pa.; R. H. Lee, Lewistown, Pa.; John Birkinbine, Philadelphia, Pa.; Percy Warner, Warner, Tenn.; J. J. Traver, Stony Creek, Tenn.; Charles H. Brown, Knoxville, Tenn.; W. H. Rood, Ishpeming, Mich.; V. K. Moore, Detroit, Mich.; J. C. Ford, Fruitport, Mich.; W. A. Miles, Copake Iron Works, N. Y.; M. Lyman, Waverly, N. Y.;

---

* A series of analyses of this ore appear in the second paper, on "*The Lake Champlain Iron Region*," in this issue.

Samuel C. Gale, Minneapolis, Minn.; H. S. Pickands, Chicago, Ill.; John W. Nesmith, Denver, Col.; Walter Crafts, Anniston, Ala.; A. R. Mackintosh, Hanging Rock, O.: H. R. Stoughton, Shelby Iron Works, Ala.; Willard Warner, Tecumseh, Ala.; H. A. Crawford, St. Louis, Mo.; W. H. Lee, St. Louis, Mo.; W. W. Jacobs, Hartford, Conn.; Charles W. Barnum, Lime Rock, Conn.; M. Hoagland, Rockaway, N. J.; I. M. Bean, Milwaukee, Wis.; C. E. Coffin, Muirkirk, Md.; George G. Lobdell, Wilmington, Del.; E. W. Crichton, Oswego, Ore.; Jacob Wissler, Max Meadows, Va.; E. Sjosdedt, Katahdin Iron Works, Me.; David Carson, New Birmingham, Tex.; J. I. White, Fort Wayne, Ind.; James L. Smith, Irondale, Washington Territory.

The recommendation of the Committee continuing the following as the Executive Committee: Joseph D. Potts, George G. Lobdell, and J. C. Fuller, was approved.

JOHN BIRKINBINE,
Secretary.

The report was adopted.

The Committee on Courtesies then made their report through the Secretary, as follows:

Resolved, That the Secretary of the United States Association of Charcoal Iron Workers be requested to express the thanks of the Association, collectively, and of the participants in the Tenth Annual Meeting, individually, to the citizens of Milwaukee, Ashland, Duluth and West Superior for the opportunities afforded the Association to view works of interest and value; and, also, for their very cordial welcome and entertainments. We cannot express the pleasure of our sojourn in their midst, and our gratitude for the many opportunities afforded us to witness the wonderful growth and prosperity of their beautiful cities; the vast mineral wealth of their section, and the manufactories and shipping facilities. We also appreciate the generous courtesies extended by the several iron and railroad companies, and express our thanks to the officers of the Chicago, Milwaukee and St. Paul; the Wisconsin Central; the Milwaukee and Northern; the Milwaukee, Lake Shore and Western; the St. Paul and Duluth, Chicago and Northwestern and the Duluth and Iron Range railroads.

We also desire to record our obligations for polite attention received from the officers of the Northwestern Iron Company, Illinois Steel Company, Milwaukee Advancement Association, Milwaukee Industrial Exposition, Wisconsin Agricultural Society State Fair, E. P. Allis & Company, Ashland Iron and Steel Company, Prentice Brownstone Company, Chamber of Commerce of Duluth, Duluth Iron and Steel Company, Minnesota Iron Car Company, Minnesota Iron Company, Chicago and Minnesota Ore Company, West Superior Iron and Steel Company, Lehigh Coal Company, Metropolitan Land and Iron Company, the Colby Mine and the Chapin Mine.

The report was adopted.

The Secretary read a letter from Mr. J. C. Ford, giving information in regard to the work of the Fruitport Furnace.

Mr. George W. Cope read a paper on the "Spirally Welded Tubes," by Mr. W. S. Mallory, who was called away by business.

A paper was also presented which had been prepared by Mr. E. Sjosdedt, of Katahdin, Me., on the "Magnetic Survey and the Magnetometer."

Messrs. Traver, Cook and McGugin then exhibited some specimens of the ore used in their furnaces.

The meeting then adjourned *sine die.*

JOHN BIRKINBINE,
Secretary.

[NOTE.—The minutes were in type for No. 5, vol. viii., but through a misunderstanding were not bound in with the other pages, and the error was not discovered until some had been mailed; hence their appearance in this number.—THE EDITOR.]

Shipments of Lake Superior Iron-Ore.

OUR readers are probably aware that the production of iron-ore during the year 1889 has been unprecedented in the Lake Superior region, nearly 7,000,000 tons having been won and shipped, but we doubt if the fact is generally appreciated that this production indicates an increase of nearly 50 per cent. over the 1888 shipments, which were also larger than those of any previous year.

In order to obtain some idea of this enormous output we may compare it with that of the famous Cornwall ore hills, in Lebanon County, Pa. The approximate production of this unique deposit from its opening in 1740 to, and including, the year 1884, was 6,808,873 gross tons, or very close to the shipments by lake during the year 1889 from the Lake Superior region (viz., 6,810,103 tons), or, to express it differently, practically as much iron-ore was shipped from the Lake Superior mines in 1889 as was won from Cornwall in nearly a century and a half. Within the past five years, however, the Cornwall ore hills supplied over 3,356,000 gross tons or 49 per cent. of the above yearly shipment, producing 769,020 gross tons of this in 1889.

The Iron Mountain, Pilot Knob, and neighboring Missouri mines, have produced about 5,000,000 gross tons of iron-ore up to date, or only about 70 per cent. of the Lake Superior shipments for one year (1889).

Including the all-rail shipments and the ore smelted in blast-furnaces near the mines, the 1889 output of the Lake Superior iron mines was in round numbers 7,000,000 gross tons, and taking the average furnace analysis as 60 per cent. of iron this would produce 4,200,000 gross tons of pig-iron, or over 50 per cent. of the total make of the country.

As most of the ore obtained from the Lake Superior mines is at one time or other hauled over some of our various railroad systems, it will be interesting to make up a statement showing what a large volume of the business of the railroads the transportation of this ore would make. Assuming an average of 500 gross tons to a train (which is rather above the average), and allowing for locomotive, tender and caboose, we find that it will require say 350,000 cars or 14,000 trains, which, standing close together, will occupy over 2200 miles of track, or these trains would be over fifty-three consecutive days passing a given point, the trains moving at the rate of 20 miles per hour, and allowing five minutes headway between trains.

The largest shipping port of this region is Escanaba, Mich., the balance of the mine product being forwarded from Ashland, Wis., Marquette, Mich., Two Harbors, Minn., Gladstone, Mich. (a new port first used in 1888) and St. Ignace, Mich. The following table will show the amount sent from and the percentages of output of each range, and the total amount and percentage shipped from the different ports during the year 1889. All of this ore was transferred from cars into docks, and thence into vessels, which carried it to receiving docks, where it was again handled:

TABLE A.

Lake Shipments from Lake Superior Mines during 1889.

Shipped from	Gross tons from Marquette Range.	Per cent.	Gross tons from Menominee Range.	Gross tons from Gogebic Range.	Per cent.	Gross tons from Vermillion Range.	Total shipments gross tons.	Per cent.
Marquette, Mich........	1,376,835	54.6	....	....	......	....	1,376,835	20.2
Escanaba "	1,021,006	40.4	1,684,618	298,008	16.7	....	3,003,632	44.1
St. Ignace "	51,853	2.1	....	....	......	....	51,853	0.8
Gladstone "	73,847	2.9	....	....	......	....	73,847	1.1
Ashland, Wis..............	....	......	....	1,484,802	83.3	....	1,484,802	21.8
Two Harbors, Minn....	....	......	....	....	......	819,639	819,639	12.0
Total......................	2,523,041	100.0	1,684,618	1,782,810	100.0	819,639	6,810,108	100.0

An inquiry as to the distribution of this ore would be most interesting, but this cannot be followed except in a general way. In round numbers, 80 per cent. of the total shipments as above were sent to ports on the south shore of Lake Erie, the remaining 20 per cent. going to the blast-furnaces at Chicago, or to those along or convenient to the shores of Lake Michigan. We have not at hand data showing the distribution of ores shipped to Lake Michigan ports, but *The Iron Trade Review* publishes a *résumé* of the receipts of ore during the past season at the nine ports on Lake Erie, which aggregated 5,314,112 gross tons, or 40 per cent. more than was received during 1888, and double what they were in 1886. Until the year 1888, Cleveland was the principal receiving port on Lake Erie, but in that year Ashtabula came to the front, and continued to hold first rank in 1889, handling close to 2,000,000 tons of ore. Cleveland held second place, with nearly 1,400,000 tons, an amount greater than ever received there before, and Fairport ranks third, with over 800,000 tons. The ports of Buffalo, Erie and Lorain, each handled over 250,000 tons, the balance of the total receipts being discharged at Sandusky, Cleveland and Huron, Sandusky taking the bulk of these. Within the last two years, Buffalo and Erie have grown very rapidly in importance, the former on account of the demand for Lake Superior ores from the eastern blast-furnaces. The furnaces in eastern Ohio and western Pennsylvania receive their supplies from Cleveland, Fairport, Ashtabula, and Erie.

A remarkable feature of the Lake Superior shipments for the year 1889 is found in the fact that although the amount of ore sent forward is greater than ever before; the iron-ore left on dock at the close of the season is 150,000 tons less than last year, all of which is practically sold. *The Iron Trade Review* states, that of the 110,000 tons unsold at the beginning of December last, 40,000 was unsaleable, and had been in stock for years, and "that the unsold ore at the close of the season 1889, ostensibly only 2.6 per cent. of the aggregate tonnage on docks, is in fact practically *nil*."

The larger Lake Superior mines, *i.e.*, those which shipped over 100,000 tons in the year 1889, are as follows in the order of their lake shipments as reported by the *Marquette Mining Journal:*

TABLE B.—LARGE PRODUCERS IN THE LAKE SUPERIOR REGION.

	Gross tons.
1. Norrie mine, Gogebic Range,	561,145
2. Minnesota Iron Company, Vermilion Range,	513,295
3. Chapin mine, Menominee Range,	503,289
4. Chandler mine, Vermilion Range,	303,200
5. Lake Superior mine, Marquette Range,	274,579
6. Republic mine, Marquette Range,	264,584
7. Cleveland mine, Marquette Range,	262,835
8. Pittsburgh and Lake Angeline, Marquette Range,	228,614
9. Ashland mine, Gogebic Range,	221,274
10. Champion mine, Marquette Range,	206,754
11. Aurora mine, Gogebic Range,	196,732
12. Florence mine, Menominee Range,	180,642
13. Iron River, Menominee Range,	173,525
14. Vulcan mine, Menominee Range,	153,556
15. Dunn mine, Menominee Range,	148,320
16. Cliffs Shaft, Marquette Range,	126,627
17. Ludington mine, Menominee Range,	106,974
18. Germania mine, Gogebic Range,	101,717
Total of 18 large mines,	4,527,662

Over 66 per cent. of the shipments of the Lake Superior region, where ninety-five mines were reported active in 1889, was therefore obtained from the eighteen large mines above mentioned. This is truly a magnificent showing, and one which has never been equalled; with the exception of the Cornwall ore hills, we do not believe that any single mining enterprise had, up to the year 1889, produced 500,000 tons of ore annually, and the Cornwall ore hills has only excelled this amount in five years. But the Norrie mine in the Gogebic Range, the Minnesota Iron Company's mines in the Vermilion Range, and the Chapin mine in the Menominee Range, each exceeded this figure in 1889, and these three mines together contributed 1,577,729 gross tons of ore, or 23 per cent. of the entire Lake Superior shipments in the year.

While the Gogebic Range heads the list of large producers, it does not again appear until the mine which stands ninth in the order of importance; and of the eighteen mines, this range contributes four with an aggregate reported shipment of 1,080,868 tons. Out of three mines in operation on the Vermilion Range, two of them are in the list of large producers, where they rank as No. 2 and No. 4, their combined output being 816,495 gross tons. The six mines in the above list, which are included in the Marquette Range, are, with one exception, grouped closely together, and five of the six report shipments varying less than 75,000 tons. The combined output of the six mines placed the Marquette Range as the largest contributor to the above 4,527,662 tons, the figure being 1,363,993 gross tons. The Menominee region differs from the Marquette in that, with the exception of the Chapin mine, none of its large producers reach 200,000 tons, and the other five do not vary over 75,000 tons. The total of the six mines is 1,266,306 gross tons.

To recapitulate we may state the case as follows: Out of a total shipment during the year 1889 from the Marquette Range of 2,523,041 gross tons, the six large mines enumerated, contributed more than one-half or 1,363,993 tons. The six large mines named in the Menominee range sent forward 1,266,306 tons out of a total shipment of 1,684,618 tons, or about three-fourths of the above. The shipments of the Gogebic Range aggregated 1,782,810 tons, of which the four large mines mentioned are credited with 1,080,868 tons or 60 per cent. of the whole.

All but 3144 tons out of a total of 819,639 tons, from the Vermilion Range came from its two large producers.

These facts will emphasize the important bearing which the large producers exert upon the record of the Lake Superior mining region, a bearing which those interested in "floating" mining properties evidently fail to appreciate. During the speculative fever which ran riot in the early history of the Gogebic Range investors were assured that each 40-acre tract was good for an annual output of 50,000 tons, and mines which were to produce 100,000 tons or more of iron-ore annually were then more numerous than subsequent results have proven them to be. The same brilliant future has been or is promised for other sections of the country, and we merely refer to the Gogebic craze as a notable instance of promise and performance. Mines which produce 100,000 tons of iron-ore annually are unusual, and notwithstanding the immense demand for ore during 1889, not more than thirty (if so many) American mines can claim to have reached this output. A property which produces 50,000 tons of iron-ore annually is a big mine—until the census statistics are collated the number of such mines cannot be given—but it may be interesting to know that in the Lake Superior region seventeen mines are credited with outputs between 50,000 and 100,000 tons in 1889. Of these ten were in the Marquette Range, two were in the Menominee Range, and five were in the Gogebic Range.

All of the above figures are taken from the reported lake shipments. When the reports are corrected for local furnace consumption, all rail-shipments, etc., there may be some changes in the relative position of the different mines, but not sufficient to affect the general conclusions.—ED.

Lake Champlain Iron Region—No. 2.

SINCE the first portion of this article was published in the JOURNAL (*vide* pages 218 to 227), an interesting and instructive bulletin has been issued by Prof. John C. Smock, of the New York State Museum, entitled, "First Report on the Iron Mines and Iron-Ore Districts of the State of New York." He divides the ores into seven districts, the second district being mentioned as the "Adirondack Region, including the Lake Champlain Mines," which therefore covers a greater area than was embraced in the district as we discussed it in the former paper. He refers to forty-six mines in this district which, according to his division, extends as far south as the magnetites in the vicinity of Fort Ann, Washington county, near the head of Lake George; as far north as the Chateaugay mines in Clinton county, and as far west as the Little River and Jayville mines in St. Lawrence county, and the Port Leyden mine in Lewis county.

The mines in the vicinity of Fort Ann, Washington county, have not been worked in late years, but the probabilities are that they will be placed in activity again, for, although some of the ores are lean, they are of Bessemer quality. We find, upon reference to the census statistics for 1880, that these mines produced over 18,000 tons in that year, the ore analyzing from 37 to 62 per cent. of iron, and the phosphorus from nothing to 0.055.

The Chateaugay mines we shall discuss in this paper. The Jayville and Little River deposits had not, until last year, been accessible on account of the want of transportation facilities, but it is probable, now, that with the railroads constructed to them, these large bodies of lean Bessemer magnetite will be brought into the market, and already arrangements are reported as being made to concentrate some of the ores on a liberal scale.

The Port Leyden mine we referred to in the JOURNAL, vol. vi., page 268, and the character of this ore, according to the analysis, will explain why it was not largely developed.

We have made this digression so as to indicate the reasons for Prof. Smock embracing all of the magnetites in what he designates as the "Adirondack Region." He says: "Magnetite is one of the common minerals in the Adirondacks, and is widely distributed, both as a constituent or accessory mineral in rocks, and in beds of workable extent. Mines have been opened in all parts of the region, but the greatest development has been in the valley of Lake Champlain, and hence the ores are known in the market as *Lake Champlain ores.* In it are the famous Port Henry mines, and others. The Chateaugay range cannot be said to lie in the Champlain valley. Therefore, the grouping by geological rather than by geographical lines alone, is more definite, and the larger district of the Adirondacks is better than any subdivisions according to our present knowledge. It is a notable fact that nearly all of the mines are on the borders, and that comparatively few ore-localities have been found in the mountainous interior. Future explorations will doubtless discover many iron-ore beds, and result in the development of other mining centres in what now appears as barren ore-territory. The construction of additional railways, affording facilities for reaching the markets, will do much to open and develop new mines.

"The magnetite, as it occurs in the Adirondack region, varies much in the degree of crystallization, in texture and in color. In the Port Henry mines it is, as a rule, rather coarsely crystalline and lustrous black. At Palmer Hill, and at Arnold Hill, martite (a hematite crystallizing as magnetite) appears to replace the latter mineral. The titaniferous ores are noted for their hardness, dull black fracture surfaces, and general fineness of grain.

"Another characteristic of the region is the great size of some of the ore-beds. The great sheet, as it were, opened in the Chateaugay slopes, the thick beds or shoots of ore at Mineville (Port Henry), the great outcrops at Adirondack, and the ridge of lean ore at Little River, are almost inexhaustible, and, with the advent of practicable concentrating processes, all of them can produce cheap ores and compete with other iron-ore districts of the country."

In the first portion of this article we divided the Lake Champlain iron region into three general groups, but devoted most of the space to the Port Henry, or middle group. We shall, in this number, refer to the others, viz., the Crown Point, which is the southern, and Chateaugay the northern group, and also note individual mines.

Before taking up these groups, we may properly insert some additional data lately obtained concerning the unusually pure ore obtained from one of these New Bed openings, referred to in the JOURNAL, vol. viii., page 225. Through the kindness of Mr. T. R. Woodbridge, chemist for Witherbees, Sherman & Co., we are able to give our readers a record of *all* the analyses made by him of the ore (about 40,000 gross tons), taken from this deposit (locally known as "Lover's Hole"), between its first development, April, 1889, to the close of the year 1889.

Analyses of Magnetite from Lover's Hole, Mineville, Essex County, New York.

No.	Per cent. of iron.	Per cent. of phosphorus.
1,	72.00*	0.018
2,	71.70	0.022
3,	71.20	0.026
4,	70.60	0.023
5,	70.40	0.011
6,	70.40	0.022
7,	70.40	0.048
8,	70.25	0.045
9,	70.20	0.021
10,	70.20	0.051
11,	69.90	0.025
12,	69.90	0.046
13,	69.50	0.013
14,	69.20	0.020
15,	69.10	0.023
16,	69.10	0.031
17,	69.00	0.025
18,	68.70	0.030
19,	68.45	0.060
20,	67.80	0.038
21,	67.70	0.054
22,	67.20	0.035
23,	67.20	0.060
24,	67.00	0.042
25,	66.70	0.030
26,	66.60	0.026
27,	66.10	0.036
28,	65.20	0.042
29,	65.10	0.048
30,	61.20	0.024
Average,	68.60	0.033
Maximum,	72.00	0.06
Minimum,	61.20	0.011

The above analyses indicate the extreme range of composition, and are arranged in the order of their iron contents instead of chronologically.

It is probable that the highest percentage of iron (72 per cent.) found in the early development of the working, was obtained from a sample in which crystals were abundant, while in the lowest one

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* Two determinations.

(viz., 61.2 per cent.) there was evidently an excess of lower grade ore after the workings had been extended or the presence of wall rock, for the next low analysis shows 66.10 per cent. of iron. The laboratory dates also prove this to have been the case. The first analysis, showing 72 per cent. of iron, was checked by a second determination. There are two analyses between 71 and 72 per cent., and seven between 70 and 71 per cent.; one-third of the determinations showing over 70 per cent. of iron.

The phosphorus contents range from 0.011 to 0.060; in the two instances in which the phosphorus reached the latter figure, the iron contents were 67.20 and 68.45 per cent., so that, in no case, does an analysis show that the phosphorus exceeds one part in 1120 of iron.

The above analyses were obtained by taking ore from each carload shipped, and sending the samples so collected to the laboratory every week or ten days. We do not know of any record of the output of 40,000 tons of iron ore which has shown such excellent analyses.

THE CROWN POINT MINES.

These consist of numerous openings located at or near Hammondville, Essex county, N. Y., about 13 miles west of Crown Point, and 1300 feet above the level of Lake Champlain. A narrow-gauge railroad connects Hammondville and Crown Point. The Penfield and Hammond openings which brought this group into prominence, and from which Prof. Smock says over 500,000 tons were won, are not now operated, but some of the numerous newer openings are credited with being on the same veins. These mines are operated by the Crown Point Iron Company, which corporation also owns two blast-furnaces at Crown Point. The ore obtained yields about 48 per cent. of iron, and is of Bessemer grade. An analysis communicated by Mr. A. L. Inman, General Manager, gives the composition as follows:

	Per cent.
Peroxide of iron,	47.38
Protoxide of iron,	21.32
Protoxide of manganese,	0.10
Alumina,	1.97
Lime,	1.18
Magnesia,	0.36

	Per cent.
Phosphoric acid,	0.08
Sulphur,	0.02
Silica,	27.48
Total,	99.89
Metallic iron,	49.74
Phosphorus,	0.035

The company are now operating six or eight mines, some of which have been followed along the dip (which is generally from 30° to 40°) for a distance of 1000 feet, and for a vertical depth of over 300 feet. In some instances the vein reaches a thickness of 20 feet, and the deposit is one of considerable value and importance. The equipment embraces some excellent machinery, and the mines can produce a large amount of ore. Mining has been carried on in the Crown Point group for over sixty years.

The total output for the last thirteen years is as follows:

Year.	Output. Gross tons.
1876,	94,612
1877,	84,132
1878,	92,852
1879,	97,576
1880, Maximum,	99,333
1881,	88,066
1882,	84,900
1883,	75,590
1884,	66,010
1885,	58,014
1886,	60,084
1887,	64,940
1888,	74,910
Total,	1,041,019

Several mines which are within short distances of Hammondville might be included in this group, but as they have not been producers in late years they need not be considered.

The third group consist of

THE CHATEAUGAY MINES.

These are situated in the town of Dannemora, Clinton county, N. Y., on the slope of Lyon Mountain. They are 34 miles west of Plattsburgh, with which they are connected by the Chateaugay railroad (3 feet gauge). The two veins of ore strike northeast and southwest, and dip at high angles to the northwest. The ore has been opened almost continuously on the main vein for a length of 2500 feet, and in twenty-two slopes. Prof. Smock says: "In the eastern slopes the depth ranges from 500 to 600 feet, and the ore is rather soft and coarse grained. A notable feature of the range is the uniformity in the wall-rocks, which carry some magnetite in the coarse-crystalline aggregate of orthoclase, vitreous quartz and hornblende. More or less feldspar and quartz occur in the ore, either in thin laminæ with the magnetite, or in scattered grains through the mass. The western slopes are from 1000 to 1100 feet long, and 650 to 700 feet deep, vertically. The average dip at the west is 45° north; at the eastern slopes, it is 70° northeast. A breadth of 20 feet of ore is won in the western slopes, leaving lean ore in the hanging- and foot-walls. In consequence of rolls in the walls, the slopes are not at uniform angles of descent, and the tracks follow the undulations of the foot-wall. Trap-dikes traverse the ore, crossing it in sheets, which are as much as 20 feet thick in some cases, and, in the western slopes, dipping steeply southward. Wherever encountered they are left as pillars to hold up the roof. Near slopes Nos. 14 and 16 they strike transversely across the vein and are vertical. The ore at the western slopes is rather finely-crystalline and harder than that at the east, although in breaking it down there is much fine ore. All of the ore is suitable for Bessemer, and the average composition of the shipping ore is shown by the following analysis:

	Per cent.
Peroxide of iron,	49.979
Protoxide of iron,	22.489
Oxide of manganese,	0.169
Alumina,	1.363
Lime,	4.049
Magnesia,	1.970
Silica,	18.447
Phosphoric acid,	0.068
Sulphur,	0.052
Total,	98.586
Metallic iron,	52.47
Phosphorus,	0.029

In mining the ore there is a considerable proportion of lean material obtained, to utilize which the separator plant located at Lyon Mountain and described in the JOURNAL, vol. viii., pages 4–13, was erected, thus producing a marketable product from what ordinarily would to a large extent be waste. A smaller separator plant at Bradley Pond augments the amount of concentrated ore produced, and has given the Chateaugay Ore and Iron Company the well-earned credit of demonstrating the practicability of concentrating ores on a large scale, and introducing separated magnetite as a commercial product.

Ten years ago we made our first visit to the mines at Lyon Mountain; then a few houses were grouped about a single compressor and hoisting plant in the course of erection. Now a pretentious settlement of miners' homes, stores, hotels, churches, numerous buildings filled with hoisting, compressing, pumping and concentrating machinery, and an army of employees, show the development of a decade, during which time about 1,500,000 gross tons of ore have been mined.

The Chateaugay Ore and Iron Company also have charcoal blast-furnaces at Plattsburgh, and at Standish on the line of the Chateaugay railroad, which is controlled by the same interest that operates the mines. They also own the Bellmont forge described in the JOURNAL, vol. ii., pages 357–360, and other forges equipped for producing iron direct from the concentrated ore. The ore-body mined by the Chateaugay Ore and Iron Company can be traced for miles, and it gives promise of continuing as an important contributor to the iron-ore product of the country.

Between the Port Henry and Chateaugay groups there are a number of mines, most of them idle, but two Clinton County deposits demand notice. These are, first:

THE PALMER HILL MINES,

near Black Brook, one and a half miles north of Au Sable Forks. There are two companies at work, the J. & J. Rogers Iron Company and the Peru Steel Ore-Company (Limited). Prof. Smock states that the Big Pit is the principal mine of the first-named company. "Its slope is 1500 feet long and 400 feet deep vertically. The extent of the opening on the course of the ore, from the Big Pit northeast to the opening on lot No. 29, is about 2000 feet. The 'shoots' of ore pitch to the north at a low angle. The dip varies on account of rolls in the walls, and in places the ore stands almost vertical. A notable feature is in the cutting of the ore by dikes. The largest is 16 feet wide, and is traced across both companies' mines, and in an easterly course on the slope of the hill. The larger part of the ore is fine granular, and carries some vitreous quartz, orthoclase, and a greenish mineral. No apatite is found and little pyrite. In the mass, it has a bluish shade; when crushed, the powder is red." Two analyses by Britton give:

	Per cent.	Per cent.
Metallic iron,	51.47	38.80
Oxygen,	19.62	14.79
Alumina,	1.86	2.20
Lime,	0.08	0.26
Magnesia,	0.62	0.80
Water,	0.43	0.45
Phosphoric acid,	0.042	0.05
Silica,	25.42	42.49
Total,	99.542	99.84

"The ore is run down a gravity road to the dump south of the mine, thence it is carted to the separating works on a stream near Au Sable Forks. It is all roasted and separated, and made into billets in the Catalan forges of the company. The product is sold to makers of crucible steel; nearly all of it goes to Pittsburgh, Pa. This mine was opened about the year 1844. The total output amounts to nearly 1,000,000 tons of ore."

THE ARNOLD HILL MINES,

are at Au Sable, one and one-half miles west of Ferrona station on the Au Sable branch railroad. Three parallel veins of ore are worked, known as the "Gray," the "Black," and the "Blue." The strike is north-northeast. The dip is 60° to 70° west-northwest. The "shoot" structure is very marked, and the "pitch" of these lenticular bodies of ore is north-northeast, at an average angle of 40°. Another remarkable feature in the occurrence is the clean and smooth walls, and the rare presence of any slabs of rock on roof or foot-wall. The veins are separated by rock, in places as much as 40 feet between the "Gray" and the "Black."

"The ore in the 'Gray,' or lowest bed, is medium fine crystalline, and carries considerable greenish mineral in it. That of the 'Black' is rather more friable and finer grained, a shot ore; although some of it is coarse crystalline; it contains some apatite in small grains. The 'Blue' ore is named from its bluish shade of color; it is also a rich ore; its crushed powder has a red color. There are two working slopes, each about 500 feet long and 500 feet apart. The whole working length is nearly 700 feet. Cross-drifts connect the levels on the three veins. The 'shoots' of ore are from 3 to 20 feet thick. Where the pinches occur pillars of ore are left. The vertical depth is 440 feet. The lower mine is no longer worked. It is a large ore-body, whose dip is nearly vertical, west-northwest. The magnetite occurs in thin alternate layers with rock, so as to be separable by sorting. The mine is about 100 feet deep. The ore is shipped *via* the Au Sable branch railway and Plattsburgh to furnaces in New York, Pennsylvania and Ohio. It is a rich non-Bessemer ore. The total output since the first opening in 1830 is estimated to be 400,000 tons."

Two analyses of this ore show:

	Per cent.	Per cent.
Metallic iron,	59.92	61.28
Phosphorus,	0.070	0.113
Phosphorus in 100 parts iron,	0.131	0.184

In closing this sketch we may note that the estimated output of the iron-ore mines in the Adirondack region of New York State, in the year 1889, is about 750,000 gross tons.

Carter County, Tennessee, Iron-ores.

AT the Tenth Annual Meeting of the United States Association of Charcoal Iron Workers, Mr. J. J. Traver, of Stony Creek, Carter County, Tenn., exhibited some specimens of the ore found in the vicinity of the Carter furnace, Tennessee, and furnished the following analyses:

1st. The Cannon mine is claimed to show outcroppings of red hematite for two and a half miles along the mountain; one lense, reported 12 feet wide, being traced for 150 feet:

	Per cent.
Iron,	67.91
Silica,	2.01
Phosphorus,	0.06

2d. The Hodge mine is a deposit of brown hematite, which is claimed to have been traced for a mile or more, and shows considerable width, the depth having been proven for 80 to 90 feet:

	Per cent.	Per cent.
Iron,	42.23	57.07
Silica,	11.00	5.35
Manganese,	8.91	......
Phosphorus,	0.175	0.225

3d. The Taylor mine is reported to be a vein of ore running through the limestone rock for about one-half a mile. It was first opened in 1844, and is 15 to 20 feet wide and 30 feet in depth.

Mr. Traver also furnished the following analyses of other East Tennessee iron- and manganese-ores:

Iron ores.	Hardin. Per cent.	Hust. Per cent.
Sesquioxide of iron,	77.47	......
Silica,	11.55	3.50
Manganese dioxide,	0.151	......
Manganese,	......	4.23
Alumina,	1.26	......
Lime,	0.44	......
Phosphorus,	0.083	0.3361
Water,	9.07	......
Total,	100.023	
Metallic iron,	54.23	52.56

Manganese-ores at head of Stony Creek, Carter County, Tenn.:

	Taylor bank. Per cent.	Garland bank. Per cent.
Iron,	3.42	4.85
Manganese,	48.91	46.44
Silica,	2.50	5.95
Phosphorus,	0.216	0.183
Copper,	present.	present.

The Southern Pig-Iron Industry.

The Tradesman in an article on "The Iron Industry" makes the following statements in regard to the growth of the manufacture of pig-iron in the Southern States. The following tables show the number and estimated capacities of the blast-furnaces :

COKE FURNACES IN THE SOUTH.

States.	Total number stacks.	Number in blast.	Capacity per week.	Out of blast.	Capacity per week.
			Tons.		Tons.
Virginia	13	10	5,113	3	1,250
Kentucky	4	1	248	3	760
Alabama	30	24	14,564	6	3,275
Tennessee	11	10	5,002	1	674
Georgia	2	1	553	1	310
Total	60	46	25,480	14	6,269
Total for United States	226	160	112,269	66	30,811

CHARCOAL FURNACES IN THE SOUTH.

States.	Total number stacks.	Number in blast.	Capacity per week.	Out of blast.	Capacity per week.
			Tons.		Tons.
Virginia	23	5	263	18	630
Kentucky	2	2	203	....	....
North Carolina	2	1	70	1	70
Tennessee	8	4	840	4	610
Georgia	2	....	....	2	114
Alabama	11	10	2,283	1	220
Texas	1	1	173	....	....
Total	49	23	3,832	26	1,644
Total in United States	154	67	12,893	87	8,302

The production of iron by States, for the year just ended, is as follows :

PRODUCTION OF IRON IN THE SOUTH, 1889.*

	Tons.
Virginia,	246,728
Kentucky,	35,140
North Carolina,	2,672
Tennessee,	295,951
Georgia,	25,155
Alabama,	785,521
Texas,	5,736
Total,	1,396,903

The growth of this industry during the decade is well shown in the following tables, giving the output in tons, each year, of the twelve Southern States :

IRON PRODUCTION OF THE SOUTH.

Year.	Tons produced.
1880,	212,722
1881,	405,133
1882,	504,055
1883,	610,862
1884,	602,368
1885,	643,828
1886,	845,677
1887,	892,009
1888,	1,018,043
1889,	1,396,903

A calculation made places the production of ore in the States of Virginia, North Carolina, Georgia, Alabama, Kentucky and Tennessee at or about 1,750,000 tons in 1886, 2,000,000 in 1887, 2,500,000 in 1888 and 3,000,000 in 1889. Of this ore fully 70 per cent. was red hematite or fossil ore, about 25 per cent. iron hematites and probably about 5 per cent. magnetic. Alabama contributed about 1,300,000 tons, Tennessee 650,000 and Virginia 500,000.

STEEL.

The Southern States have, as yet, done little in the manufacture of steel, owing to the absence of the Bessemer ores needed, but two projects are now on foot looking to the introduction of this manufacture,—one, that of the Southern Iron Company, which proposes to construct two open-hearth furnaces at Chattanooga with a daily capacity of 40 tons, the work to begin in January, and the manufacture of the steel itself—(for steel for boiler plate, nail plate, etc.)—the other proposes to import high grade Bessemer ores from Cuba by way of Pensacola, bringing them in exchange for the Alabama coal now shipped to the island.

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* Estimated for a portion of the time.

Swedish Mineral Statistics.

THROUGH the courtesy of Prof. Rich Akerman, of Stockholm, Sweden, honorary member of the Association, we are supplied with the following official statistics of the iron and steel industries of Sweden:

PRODUCTION OF IRON AND STEEL IN SWEDEN, METRIC TONS.

	1882.	1883.	1884.	1885.	1886.	1887.	1888.	Percentage of increase or decrease of 1888 ov'r 1887.
Iron-ore	892,863	885,124	909,553	873,362	872,479	903,186	959,540	+ 6.2
Charcoal pig-iron	398,945	422,627	430,584	464,787	442,457	456,625	457,052	+ 0.1
Bar iron and rods made	259,462	255,858	264,944	257,369	237,130	255,383	263,090	— 0.9
Bessemer iron and st'l made.	47,358	50,878	53,123	52,021	54,121	68,199	68,620	+ 0.6
Martin iron and steel made.	13,405	16,800	19,354	26,743	22,361	41,898	44,712	+ 6.7
Other kinds of steel made	1,430	1,827	1,764	1,786	1,749	1,468	1,205	—17.9
Plates made	15,805	17,439	17,034	16,494	13,579	12,894	19,701	+59.2
Nails made	8,143	8,197	9,720	10,577	10,289	10,239	10,683	+ 4.3
Number of blast-furnaces in operation	185	191	178	179	164	164	162	— 1.2
Total time for all furnaces in blast, days	40,157	41,229	40,361	42,460	39,777	40,582	39,840	— 1.9
Average time for furnaces in blasts, days	217	216	227	237	242.5	247.5	246	— 0.6
Average production per furnace and day	9.93	10.25	10.67	10.95	11.12	11.23	11.47	+ 2.1

The statistics of Swedish iron production and manufacture are generally a year or more behind our own in publication—this accounts for the absence of figures for the year 1889. Our readers will probably be most attracted by the constant advance during the seven years which is shown by the average production per furnace per day, an advance more marked by its regularity than by its rapidity—the increased product per furnace per day being 15 per cent. greater in 1888 than it was in 1882.

For the last column, viz., percentage of increase or decrease, 1888 over 1887, we are responsible. EDITOR.

Iron and Steel Manufacture at Chicago.

THE following extracts are taken from an article in the *Age of Steel* on "The Growth of the Iron and Steel Industry in the West," by Mr. E. C. Potter:

"The birth of the iron and steel industry in the West dates from the establishment, in 1855, of an iron rolling-mill, with two small charcoal blast-furnaces at Wyandotte, Mich., a suburb of the city of Detroit, by Capt. E. B. Ward, of that city, and the subsequent extension of this enterprise by the construction of a similar mill, in 1857, on the north branch of the Chicago River, by the same parties. The Union iron-mill was built on the south branch of the Chicago River in 1863. The Milwaukee Iron Company was built in Milwaukee by Capt. Ward in 1868.

"The first heat of Bessemer steel ever made in America was blown at an experimental plant at the Wyandotte mill in 1865, and the ingots were sent to Chicago, and rolled at the North Chicago mill, into rails, that same year.

"The first Bessemer plant in the West was built at the Union works; the first blow being made in 1871. Closely upon this followed a similar Bessemer plant built at the North Chicago works, the first blow being made in 1872.

"In 1869 Capt. Ward's mills in Chicago were incorporated under the name of the North Chicago Rolling-Mill Company, and that same year two blast-furnaces were built at these works, which, at that time, were among the largest and best-appointed furnaces in America, producing at that date 250 tons of iron per week, each.

"In 1870 the Joliet Iron and Steel Company built and operated an iron rolling-mill in the city of Joliet, Will County, Illinois; and in 1873 a Bessemer steel plant similar in size and construction to those at the Union works and North Chicago works was built and put in operation.

"In 1880 the North Chicago Rolling-Mill Company finding its capacity too limited, and its machinery growing out of date, began the construction of a large and modern steel rail-plant, at South Chicago, which began operations in June, 1882. This plant consisted of four large blast-furnaces; a Bessemer plant and rail-mill, which were then the largest of their kind in America.

"In 1889 the consolidation of all the works in Chicago, Milwaukee and Joliet, under the name of the Illinois Steel Company, was effected.

"The small iron rolling-mill of 1857, making 300 tons of iron rails per week, we find expanded in thirty years to a mill capable of making 6000 tons of steel rails per week, or just twenty times the capacity of the original mill. Three hundred tons of rails, which was the weekly capacity in 1857, have actually been rolled in a modern mill, in the hours included between 6 o'clock in the morning and 12 o'clock noon; thereby doing in six hours what it once took six days to accomplish.

"Equally great strides have been made in the producing capacity of the blast-furnaces. The same furnace which in 1869 was making 250 tons of iron a week, in 1889, with absolutely no change whatever in the furnace or in its equipment, but simply with the improvement derived from better knowledge, was made to yield over 700 tons per week; and the same blast-furnace, with the single addition or a single change in its hot-blast stoves, from iron-pipe stoves to modern fire-brick stoves, is made to produce 1100 tons per week.

"The most remarkable feature of the history of the iron and steel trades is the rapid progress in the position occupied by the Western States, particularly the State of Illinois, and more particularly the city of Chicago, among iron-producing localities in America.

"Previous to 1870 it was hardly recognized that any iron was produced in this locality. Pennsylvania and Ohio were the great iron manufacturing States, and the city of Pittsburgh has ever been looked upon as the iron producing centre of America. It is noteworthy, therefore, to find the statistics showing that the city of Chicago, in 1887, produced more steel than the county of Allegheny, in which the city of Pittsburgh is situated, and this same pre-eminence is maintained in the years 1888 and 1889; and we find that Cook county, and the county of Will, which includes all the works in the city of Chicago, together with the works of the city of Joliet, produced more steel than Allegheny county and Cambria county, Pennsylvania, together; which counties include all the works of the city of Pittsburgh and adjoining towns, and the large establishment of the Cambria Iron Company of Johnstown.

"We find further, that the State of Illinois, which practically means the city of Chicago, including the works at Joliet, now produce more than one-fourth of all the iron and steel in America; and that the works owned by the Illinois Steel Company, which includes all the works heretofore mentioned in the brief chronological table given above, have a capacity for making one-third of all steel rails that can be made in America.

"A singular fact connected with these statements is that nowhere within the limits of the city of Chicago, or its neighborhood, or indeed in the State of Illinois, does there exist any of the raw materials required for the manufacture of iron and steel. All the ores necessary are brought a distance of 350 miles, from the Lake Superior region; and all the fuel for iron smelting is brought a distance of nearly 600 miles from the Connellsville district, Pennsylvania."

Comparison of Metric and Customary Standard Weights and Measures.

THE United States Coast and Geodetic Survey has lately issued tables for converting United States weights and measures from the customary to the metric standard and *vice versa*. As the metric system was legalized in the United States in 1866, as the standard metre has lately been deposited with the Coast and Geodetic Survey, and as the use of the decimal system is becoming more common daily, we have thought it would be of interest to our readers to extract from this table the standard comparative values of the units of each system, which are given below.

CONVERTING THE CUSTOMARY INTO THE METRIC SYSTEM.

Linear Measure.

1 inch = 25.4 millimetres.
1 foot = 0.304801 metre.
1 yard = 0.914402 metre.
1 fathom = 1.829 metres.
1 chain = 20.1169 metres.
1 mile = 1.60935 kilometres.
1 nautical mile = 1.85327 kilometres.

Square Measure.

1 square inch = 6.452 square centimetres.
1 " foot = 9.290 square decimetres.
1 " yard = 0.836 square metre.
1 acre = 0.4047 hectares.
1 square mile = 259 Hectares.

Cubic Measure.

1 cubic inch = 16.387 cubic centimetres.
1 cubic foot = 0.02832 cubic metres.
1 cubic yard = 0.765 cubic metres.
1 bushel = 0.35242 hectolitres.

Capacity.

1 fluid dram = 3.70 millilitres or cubic centimetres.
1 fluid ounce = 29.57 " " " "
1 quart = 0.94636 litres.
1 gallon = 3.78544 litres.

Measure of Weight.

1 grain = 64.7989 milligrammes.
1 avoirdupois ounce = 28.3495 grammes.
1 troy ounce = 31.10348 grammes.
1 avoirdupois pound = 0.45349 kilogrammes.

CONVERTING METRIC TO CUSTOMARY SYSTEM.

Linear Measure.

1 metre = 39.37 inches or 3.28083 feet or 1.093611 yards.
1 kilometre = 0.62137 ~~square~~ mile.

Square Measure.

1 square centimetre = 0.1550 square inch.
1 square metre = 10.764 square feet or 1.196 square yards.
1 hectare = 2.471 acres.

Cubic Measure.

1 cubic centimetre = 0.0610 cubic inch.
1 cubic decimetre = 61.023 cubic inches.
1 cubic metre = 35.314 cubic feet or 1.308 cubic yards.

Measures of Capacity.

1 millilitre or cubic centimetre = 0.27 fluid dram.
1 centilitre = 0.338 fluid ounce.
1 litre = 1.0567 quarts.
1 dekalitre = 2.6417 gallons.
1 hektolitre = 2.8375 bushels.

Measures of Weight.

1 milligramme = 0.01543 grain.
1 kilogramme = 15432.36 grains or 2.20462 avoirdupois pounds.
1 gramme = 0.03215 troy ounce.
1 hectogramme = [100 grammes] 3.5374 avoirdupois ounces.
1 quintal = 220.46 avoirdupois pounds.
1 millier or tonne = 2204.6 avoirdupois pounds.

Mr. T. C. Mendenhall, Superintendent of the United States Coast and Geodetic Survey, states that the yard in use in the United States is equal to the British yard. The grain troy is the same as the grain avoirdupois, and the pound avoirdupois in use in the United States is equal to the British pound avoirdupois. The

British gallon is 4.54346 litres, and the British bushel is 36.3477 litres. The litre is equal to a cubic decimetre of distilled water at its maximum density, which will conterpoise a standard kilogramme in a vacuum.

Our readers will find the following approximate equivalents useful in calculations; they are presented merely as suggestions of comparative values, and not as absolute equivalents:

25½ millimetres = 1 inch.
3 metres = 10 feet.
16 kilometres = 10 miles.
1 hectacre = 2.5 acres.
1 cubic metre = 35 cubic feet.
10 cubic metres = 13 cubic yards.
35 hectolitres = 10 bushels.
1 litre = 1 quart.
1 kilo = 2⅕ pounds.
1 quintal = 2 cwt. [gross].
1 millier or tonne = 1 gross ton nearly.

Production of Pig-Iron in the United States in 1889.

THE *Bulletin* of the *American Iron and Steel Association* published on January 22, 1890, detailed statistics of the production of pig-iron in the United States during the year 1889, an achievement in the collection of statistics which we believe has never been equalled. The twenty-four States which contributed to the manufacture of pig-iron produced an aggregate of 8,517,068 net tons, equivalent to 7,604,525 gross tons, against 6,489,738 gross tons in 1888, an increase of over 17 per cent., viz., 1,114,787 gross tons. This production was fairly distributed throughout the year, and, in addition, the stocks of pig-iron in makers' hands was considerably less at the close of 1889 than it was at the close of 1888. Of the total amount of pig-iron produced, 5,952,414 net tons were made with bituminous coal and coke; 1,575,996 tons were made with anthracite coal and coke; 344,358 tons were made with anthracite coal alone, and 644,300 tons were made with charcoal.

The proportion which the iron made with each of these fuels bears to the total output is as follows:

Fuel.	Amount, net tons.	Per cent.
Bituminous coal and coke,	5,952,414	69.89
Anthracite coal and coke,	1,575,996	18.50
Anthracite coal alone,	344,358	4.04
Charcoal,	644,300	7.57
Total,	8,517,068	100.00

Five hundred and seventy blast-furnaces reported their operations to the American Iron and Steel Association, of which 226 were idle on December 31, 1889, leaving 344 active, but on June 30, 1889, only 287 furnaces were reported active, and it is probably fair to assume an average of about 315 furnaces for the year, which would show that the blast-furnaces in the United States produced about 27,039 net tons each. Of the 143 charcoal blast-furnaces in the United States, 80 were inactive during the year, and 63 contributed the average output of of 10,068 net tons to make the total of 634,300 tons.

Similarly, we may consider 160 coke furnaces active during the year to produce 5,952,414 net tons, or 37,203 net tons per furnace. And 90 furnaces using anthracite coal, or anthracite coal and coke, made 1,920,354 net tons, an average per furnace of 21,337 net tons. These figures are, of course, approximate, but they go to show the progress we are making in the output per furnace.

Of the total amount of pig-iron made, 86,812 net tons were spiegeleisen or ferro-manganese, a material increase over 1888, when 54,769 net tons were made; but the most marvellous increase has been in the output of Bessemer pig-iron, which increased from 1,946,826 net tons in 1888 to 3,529,584 net tons in 1889.

In the *Directory* to the Iron and Steel Works in the United States, lately published, Mr. Swank gives the number and capacity of the furnaces using different fuels, as follows:

190 anthracite furnaces,	Capacity, 3,723,333 net tons.
239 bituminous furnaces,	Capacity, 8,223,500 net tons.
146 charcoal furnaces,	Capacity, 1,221,400 net tons.

Making a total of 575 blast-furnaces, with a capacity of 13,168,233 net tons; therefore, according to the above statistics, our blast-furnaces produced the following proportions of their reported capacity:

Fuel used.	Production.	Reported capacity.	Per cent.
Anthracite furnaces, ...	1,920,354	3,723,333	51.59
Bituminous furnaces, ...	5,952,414	8,223,500	72.38
Charcoal furnaces, ...	644,300	1,221,400	52.75

"Of course, it is never possible in actual production to come at all near to the aggregate capacity; but the increase in capacity in the last two years has been very great, and when considered in connection with the additional capacity of the furnaces now building, it may be regarded as fully demonstrating our ability to meet any demand which the country may make upon our blast-furnaces for pig-iron of any quality, spiegeleisen and ferro-manganese being, for the present, excepted. The aggregate capacity of the blast-furnaces of the United States at the close of 1889 is not only much larger than it was two years ago, but the average capacity is also much larger. In November, 1887, the average capacity of all the furnaces which were then active, or likely to be some day active, was 18,885 net tons per annum, or 363 net tons per week; in November, 1889, the average capacity of furnaces in the same list was 22,901 net tons per annum, or 440 net tons per week. These figures indicate great progress in the last two years."

Pig-iron was produced with anthracite coal and coke in three States, viz., New York, New Jersey, and Pennsylvania. Pig-iron was made with bituminous coal and coke in fifteen States, and charcoal was employed in making pig-iron in nineteen States.

The following table will show the output of pig-iron in net tons for the past six years according to the fuel used.

NET TONS.

Fuel Used.	1884.	1885.	1886.	1887.	1888.	1889.
Anthracite Coal....................	1,586,453	1,454,390	2,099,597	2,338,389	1,925,729	1.920,354
Charcoal..............................	458,418	399,844	459,557	578,182	598,789	644,300
Bituminous coal and coke...	2,544,742	2,675,635	3,806,171	4,270,635	4,743,989	5,952,414
Total..............................	4,589,613	4,529,869	6,365,328	7,187,206	7,268,507	8,517,068

And the production by States according to fuel used in the year 1889, as compared with the output in 1888 is also presented below together with the number of furnaces reported on the active list in each State.

PRODUCTION OF PIG-IRON ACCORDING TO FUEL USED IN 1889, NET TONS.

States.	Total number of furnaces.	Produced with charcoal.	Produced with bituminous coal.	Produced with anthracite coal.	Total produced in 1889.	Increase or decrease from total production in 1888.
Maine	1	5,200	....	....	5,200	— 374
Massachusetts	4	7,751	....	....	7,751	— 5,497
Connecticut	8	24,143	....	....	24,143	+ 2,499
New York	39	19,084	65,661	212,502	297,247	+ 40,067
New Jersey	18	....	....	125,693	125,693	+ 23,811
Pennsylvania	228	15,951	2,583,132	1,582,159	4,181,242	+ 592,056
Maryland	15	16,285	17,562	....	33,847	+ 16,241
Virginia	32	8,967	242,389	....	251,356	+ 53,960
North Carolina	2	2,898	....	....	2,898	+ 498
Georgia	5	2,273	25,286	....	27,559	— 11,838
Alabama	45	110,427	680,998	....	791,425	+ 341,933
Texas	1	4,544	....	....	4,544	— 2,043
West Virginia	6	....	117,900	....	117,900	+ 22,641
Kentucky	7	6,786	35,732	....	42,518	— 14,272
Tennessee	19	50,224	244,431	....	294,655	+ 26,724
Ohio	74	22,467	1,193,105	....	1,215,572	+ 111,754
Indiana	2	....	9,839	....	9,839	— 5,421
Illinois	16	....	602,024	....	602,024	+ 22,717
Michigan	26	214,356	....	....	214,356	+ 1,105
Wisconsin	10	80,467	78,167	....	158,634	+ 42,597
Missouri	8	32,680	53,510	....	86,190	— 5,593
Colorado	2	....	2,678	....	2,678	— 18,199
Oregon	1	9,426	....	....	9,426	+ 6,917
Washington	1	10,371	....	....	10,371	+ 6,278
Total for 1889	570	644,300	5,952,414	1,920,354	8,517,068	+ 1,248,561
Total for 1888	589	598,789	4,743,989	1,925,729	7,268,507	+ 81,301

It will be noticed that Pennsylvania still maintains her preeminence, and that Ohio keeps second place, that Alabama in 1889 produced more pig-iron than Illinois and these two States changed places. Similarly, New York made more pig-iron in 1889 than did Tennessee, and these two States changed places, and Virginia has taken rank ahead of Michigan.

Dividing the production according to geographical lines we find that the following amounts of pig-iron were made which represent the percentages of the total output for the district named.

District.	Tons made.	Percentage of total.
New England States	37,094	0.44
Middle States	4,638,029	54.44
Southern States (south of the Potomac and Ohio Rivers and east of the Mississippi)	1,528,311	17.95
Central States (north of the Ohio River and east of the Mississippi)	1,986,069	23.32
Western States (all west of the Mississippi River)	327,565	3.85

Comparing these with the output of 1888, we have the following table.

	New England States.	Middle States.	Southern States.	Central States.	Western States.	Total.
Percentage of the total make in 1889	0.44	54.44	17.95	23.32	3.85	100
Percentage of the total make in 1888	0.6	54.6	15.3	29.1	0.4	100
Total make in net tons in 1889	37,094	4,638,029	1,528,311	1,986,069	327,565	8,517,068
Total make in net tons in 1888	40,466	3,965,854	1,115,252	2,119,456	27,479	7,268,507
Increase of product in 1888 over 1887		672,175	413,059		300,086	1,248,561
Decrease of product in 1888 over 1887	3,372			133,387		

We have shown above that the output of our blast-furnaces in 1889 do not approach their reported capacity, and we have continuously claimed in the JOURNAL, that our production of pig-iron has never equalled our consumption ; to demonstrate this again we call attention to the following figures.

	Net tons.
Stocks of unsold pig-iron, December 31st, 1888,	336,118
Total domestic product for the year 1889,	8,517,068
Total importation of foreign pig-iron from the year 1889,	159,298
Making a total available supply of,	9,012,484
From which deduct the total stock on hand, December 31, 1889,	277,401
Leaving as the apparent consumption of pig-iron for 1889,	8,735,083

This is 1,244,031 net tons above that of the apparent consumption of pig-iron in the year 1888 (viz., 7,491,052 tons).

Of the stocks of unsold pig-iron 86,772 net tons are credited to bituminous furnaces, 77,502 to the anthracite furnaces, and 113,127 to the charcoal furnaces.

In this connection we call attention to the graphic statement on page 174, vol. viii., of the JOURNAL, from which it will be noted that the importations for 1889 were less than in any year since 1878, and that with the exception of the year 1886, the stocks on hand have not been as low since 1881 as they were in 1889.

CHARCOAL PIG IRON.

The output of charcoal pig-iron in 1889, viz., 644,300 net tons, is only exceeded by that of 1882, when 697,906 net tons were made. The next largest production of charcoal pig-iron was in 1881, when 638,838 net tons were made.

The product of the charcoal blast-furnace, according to States, and the per cent. of the total output is as follows:

States.	Production in 1888. Net Tons.	Per cent. of Total.
Michigan,	214,356	33.3
Alabama,	110,427	17.1
Wisconsin,	80,467	12.5
Tennessee,	50,224	7.8
Missouri,	32,680	5.1
Connecticut,	24,143	3.8
Ohio,	22,467	3.5
New York,	19,084	2.9
Maryland,	16,285	2.5

States.	Production in 1888. Net Tons.	Per cent. of Total.
Pennsylvania,	15,951	2.5
Washington,	10,371	1.6
Oregon,	9,426	7.4
Virginia,	8,967	
Massachusetts,	7,751	
Kentucky,	6,786	
Maine,	5,200	
Texas,	4,544	
North Carolina,	2,898	
Georgia,	2,273	
	644,300	100.0

Michigan still holds first place, with a maximum output of 214,356 net tons; the next largest production being in 1887, when 213,543 tons were made.

Alabama comes next, also increasing her 1887 output of 96,223 tons, which up to this year was the largest, and making 110,427 net tons. These two States produced over one-half of the charcoal pig-iron made in 1889.

Wisconsin also made her maximum output in 1889, jumping from 69,757 net tons in 1888 to 80,467 tons in 1889, and still holds third place.

Missouri follows next in order with a product of 32,680 net tons.

Connecticut has changed places with Ohio, pushing the latter down to sixth place. The makes being 24,143 and 22,267 tons, respectively.

New York, Maryland and Pennsylvania maintained the same relative positions which they held in 1888, the other States following in the order given above.

Production of Pig-Iron in Germany.

We have excerpted the following statistics in regard to the production of pig-iron in Germany from the February number of *Stahl und Eisen :*

Pig-Iron Production of the German Blast-Furnaces in 1889.

Tons of 1000 Kilos.*

	Puddle pig-iron and spiegeleisen.	Bessemer pig-iron.	Thomas pig-iron.	Foundry pig-iron.	Total pig-iron made in 1889.	Total pig-iron made in 1888.
January	173,585	34,770	110,232	48,524	367.111	346,962
February	155,060	33,691	105,630	40,531	334,912	338,841
March	177,109	39,878	120,352	43,161	380,500	359,772
April	170,059	36,701	120,670	45,312	372,742	349,880
May..............	152,650	21,514	93,788	38,347	306,299	360,855
June	153,343	32,150	107,839	37,480	330,812	350,404
July	173,593	35,528	117,391	44,955	371.467	354,111
August	178,158	30,039	126,272	44,031	378,500	354,004
September......	173,367	30.162	120,552	49,104	373,185	353,812
October	181,266	36,148	128,302	45,621	391,337	362,006
November......	175,108	41,121	127,030	45,857	389,116	343,971
December	184,379	33,788	124,386	48,970	391,523	354,866
Total in 1889	2,047,677	405,490	1,402,444	531,893	4,387,504	4,229,484
Per cent. 1889	46.6	9.3	32.	12.1	....	....
" 1888	48.8	9.3	29.5	12.4	....	....

The official statistics of the production of pig-iron in the last 10 years in the German Empire are set forth in the accompanying table:

Year.	Tons.*
1879, ...	2,226,587
1880, ...	2,729,038
1881, ...	2,914,009
1882, ...	3,380,806
1883, ...	3,469,719
1884, ...	3,600,612
1885, ...	3,687.433
1886, ...	3,528,658
1837, ...	4,023,953
1888, ...	4,337,121

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* Tons of 1000 kilos (2204.62 pounds).

Iron-Ore Concentration, No. 5.

CONCENTRATED iron-ores are usually considered as those which have passed through sizing and jigging or sizing and magnetic separating processes, and the term is more commonly applied to magnetites than to hematites, but we may properly consider any method of beneficiating iron-ores in this discussion.

In other words, we may refer here to any means of increasing the percentage of iron in an ore by separating from it all or a part of its gangue under the general caption of concentration, and therefore in this category, washing or jigging processes may be considered. The roasting of iron-ores is to a certain extent a concentrating process, but their purpose is seldom one of separating the gangue from the ore, but rather of driving off moisture, sulphur, or carbonic acid ; and this treatment is generally recognized as that of "roasting or calcination." The system of washing brown hematites approaches in results those obtained by jigging and may fairly be considered under the general head of concentration.

Various forms of ore-washers have been referred to in the JOURNAL, vol. v., page 102, in the description of the Cripple creek region in Virginia. In vol. v., page 366, as used in the Salisbury region, Connecticut. One in use at the Shelby Iron Works, Alabama, was illustrated in vol. vi., page 578, and one used at the Copake Iron Works was illustrated and described in vol. vii., pages 6 to 11.

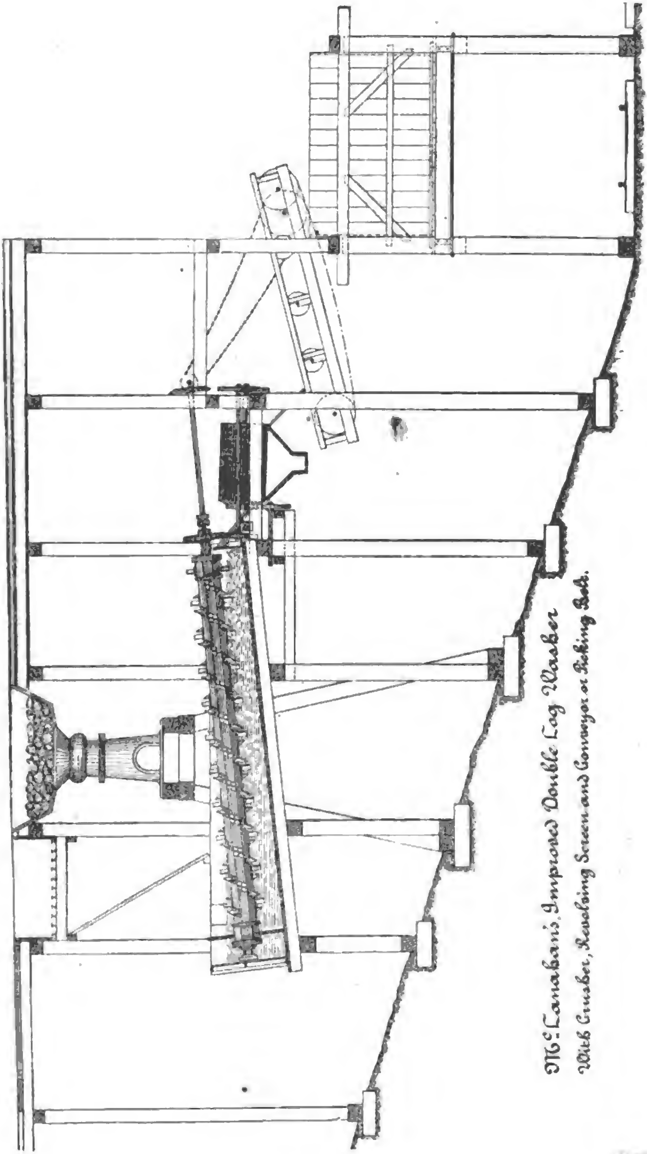
The use of the washer has developed more largely in Virginia, Georgia, Alabama and Tennessee, than elsewhere lately, but the forms principally employed are either the shaft or the cone washers. The shaft washers are single or double, the latter being preferred, and consist of one or two logs of wood iron bound and fitted with blades ; these logs revolve in a trough in which the ore and water are placed, the revolving blades cutting up the clay lumps, and forcing the ore up the inclined bottom of the trough, the water carrying away the clay to suitable settling reservoirs or mud dams.

In some instances iron shafts have been used in place of logs, and the most approved arrangement is to have paddles which slip into sockets secured to the shaft, in place of securing the blades directly to the shaft. The accompanying illustration shows an arrangement of washer of which a number have been erected in central Pennsylvania, in Virginia, Tennessee, and Alabama, by the Gaysport foundry, of Hollidaysburg, Pa. The ore as brought from the workings is discharged from mine cars on a "grizzly" through which all but the lumps pass into the trough. These lumps are fed into a crusher and from this also drop into the trough, unless it is desired to ship them without washing. As, however, considerable clay adheres to or is enclosed in the nodules of brown hematite ore, the washing of the broken lumps is advisable. As the blades cut or push the ore forward in the trough, it is met by a stream of water and the clay is washed away, the ore passing out at the upper end of the trough into a revolving screen in which a final rinsing by water takes place, and in which the finer ore or sand is separated, the coarse ore passing on to an inclined conveyor which serves as a table from which any foreign material may be hand-picked.

In some instances all the fine ore which will pass through one-inch round holes is, after washing, treated in jigs, as described in the JOURNAL, vol. viii., p. 42, when discussing the process used at Iron Mountain, Missouri.

An advantage claimed for this washer is, that it embraces the principal feature of the submerged log-washers, logs being placed on an incline of from two to three feet in their length, thus practically submerging the logs nearly one-half their length, the back-end of the washer-box being 4 feet high. The logs are 17 to 18 inches in diameter, and generally 30 feet long, covered with iron their entire length. The teeth are made with detached bases, the bases being secured to the logs so that the chilled teeth may be renewed without disturbing the bases. The logs are provided with flanged gudgeons, the back or lower gudgeon being protected with a chilled thimble, which runs in a chill step or bearing.

The logs are both driven from the front or discharge-end by spur and bevel-gearing. Two or more washers may be set side by side, all driven by the same main-line shaft, with countershafts to each washer, this countershaft being fitted with a shifting-clutch so that any one machine may be readily stopped without interfering with the operation of the others.



McLanahan's Improved Double Log Washer

With Crusher, Revolving Screen and Conveyor or Picking Belt.

A circular issued by McHanahan & Stone descriptive of jigs makes the following statement:

"Many furnace-men have never attempted to estimate the cost of smelting the foreign material contained in their ores. It is not unusual to find furnaces using ore containing 20 per cent. of foreign matter that might be taken out by a good jig, and it will be generally found to pay to use jigs if only 5 per cent. or less of foreign matter can be removed. In estimating the cost of using low-grade ores in a blast-furnace, not only the cost of coke, lime and furnace labor required to smelt this barren material must be considered, but the cost of freight, handling and storage, and taking care of increased amount of cinder. It also decreases the available capacity of the furnace.

"As the commercial value of ore becomes generally regulated by its analysis, it will be found necessary to give more thought to the proper dressing of the silicious hematites, and it must be remembered that the value of ore depends not only on the metallic iron, but also on the limit of silica.

"The market value of ore varies in the different parts of this country more than the price of pig-iron. Formerly but little difference was made in the price of high- and low-grade ore but gradually all ores are being held at more nearly their real value, and this difference in value varies with cost of coke, labor and all other expenses outside of ore, and if it is possible to increase the metallic iron 5 units, and secure a corresponding decrease in silica by the use of jigs, they would prove profitable investments." The same authority suggests the following general rule for determining the value of brown hematite ores at the mine.

"RULE.—For each unit of increase in metallic iron add one-twentieth of one cent per unit to selling price; and for each unit that silica is lowered add one-tenth of one cent to selling price. Thus, if ore before jigging analyzes, iron, 42, silica, 22, and sells for 3 cents per unit, or $1.26 per ton—if this ore is improved by the jigs to iron, 50, silica, 12, the increase in iron, 8 units, at one-twentieth of a cent per unit, equals four-tenths of a cent, and decreased silica 10 units at one-tenth cent per unit—equals 1 cent. Making total price for jigged ore per unit 4.4 cents. Fifty per cent. ore, at 4.4 cents per unit, equals $2.20 per ton—an increase of 94 cents per ton."

The following analyses of brown hematite ores before and after jigging are presented.

Ore before jigging—metallic iron, 31.72. Insoluble residue, 48.82.
Same ore after jigging—metallic iron, 51.465. Insoluble residue, 15.3.
Ore before jigging—metallic iron, 43.20. Insoluble residue, 26.40.
Same ore after jigging—metallic iron, 50.59. Insoluble residue, 16.53.

Where phosphorus exists as apatite it is often reduced by washing and jigging the ore, thus bringing some non-Bessemer hematites nearer to, or within the Bessemer limit.

We had hoped in this issue to have given late results of concentration by magnetic separators, but at the request of parties interested we defer this data until the average of longer runs can be given. We may, however, note that considerable progress is being made towards placing concentrates on the market as a regular source of iron-ore supply, and some excellent results have been obtained.

The new plant at the Croton Mines, New York, is now in operation, using the Buchanan and Croton Magnetic Separators; the concentrating works near Bechtelsville, Pennsylvania, is now separating a very lean magnetite by the use of the Edison Separator, and at Michigamme, Michigan, the Wenstrom Magnetic Separator is being worked to utilize a large dump pile. A large concentrating plant is in course of erection in New Jersey, two others are approaching completion in northern New York, and a third is being remodelled in southern New York.

Before the close of the year 1890 we believe that works will be in operation capable of producing an aggregate of 1000 tons of iron-ores daily, concentrated by magnetic methods.

◆

MR. ALEXANDER POURCEL has, it is reported, succeeded, at the new basic open-hearth steel works of Bell Brothers, in producing from Middlesbrough pig-iron, carrying 1.7 per cent. of silicon and as much phosphorus, steel with as low as 0.03 per cent. of phosphorus. The lining of the furnace is of chrome-ore.

Book Notices.

DIRECTORY OF THE IRON AND STEEL WORKS OF THE UNITED STATES.

SINCE our last issue the tenth edition of the "Directory to the Iron and Steel Works of the United States" has been published by the American Iron and Steel Association, and Mr. James M. Swank, the compiler, has made it even more valuable than former issues. It contains complete lists of the blast-furnaces, rolling-mills, Bessemer steel-works, Clapp-Griffiths steel-works, Robert-Bessemer bloomaries, cut-nail works, wire-rod and wire-mills, wire-nail works, car works, car-axle works, car-wheel works, locomotive works, and cast- and wrought-iron pipe works, in the United States. These lists are accompanied by an index of the blast-furnaces, rolling-mills, steel-works, forges and bloomaries which are described, and by another index of the companies, firms and individuals by whom these works are operated.

Commenting upon the late development in the iron and steel industries, Mr. Swank says: "Never before in all our experience have there been in the same period of time so many changes, and so many new enterprises. Notwithstanding the very low prices for many iron and steel products which prevailed during 1888 and the first half of 1889, these two years were the most active in our history in the extension of our facilities for the manufacture of iron and steel in all forms. The great activity in American iron trade during the last two years has been chiefly noticeable in the erection of blast-furnaces in the Southern States, and in the erection of steel works in the Northern States. There has also been observable in these two years a marked tendency to increase the capacity of individual establishments, and to consolidate and extend existing blast-furnace, rolling-mill, and steel-making enterprises."

The "Directory" gives a grand summary from which we excerpt the following, which tells a wonderful story of progress. Every department of iron and steel manufacture there enumerated, with the exception of Clapp-Griffiths converting plants, the output of crucible steel ingots, and the production of blooms and billets made with charcoal showing a decided increase.

GRAND SUMMARY.

	November, 1889.	November, 1887.
Number of completed blast-furnaces; 239 bituminous, 190 anthracite and coke, 146 charcoal; total,	575	582
Number of blast-furnaces building in November, 1889: 17 bituminons, 3 anthracite, and 7 charcoal; total,	27	30
Annual capacity of completed blast-furnaces, net tons,	13,168,233	10,990,993
Number of completed rolling-mills and steel-works,	445	433
Number of rolling-mills and steel-works building,	11	12
Number of single puddling-furnaces (a double furnace counting as two single ones),	4914	4882
Number of heating-furnaces,	2733	2686
Number of trains of rolls,	1510	1486
Annual capacity of completed rolling-mills, net tons,	9,215,000	8,265,000
Number of rolling-mills having nail-factories,	75	81
Number of nail-machines,	6066	6350
Number of completed standard Bessemer steel-works,	41	35
Number of Bessemer converters in November, 1889 and 1887,	88	74
Annual capacity (built and building) in ingots, net tons,	5,600,000	4,750,000
Number of Clapp-Griffiths converters,	14	15
Annual capacity (built and building) in ingots, net tons,	200,000	225,000
Number of completed Robert-Bessemer steel-works,	7	...
Number of Robert-Bessemer converters in November, 1889: 11 completed and 3 building,	11	...
Annual capacity (built and building) in ingots, net tons,	125,000	...
Number of completed open-hearth steel-works,	56	50
Number of open-hearth steel-works building,	5	3
Number of open-hearth furnaces in November, 1889: 116 completed, 23 building, and 2 standing nearly completed,	116	94

	November, 1889.	November, 1887.
Annual capacity (built and building) in ingots, net tons,	1,200,000	815,000
Number of completed crucible steel-works,	43	41
Number of steel melting pots in completed works,	3378	3398
Annual capacity in ingots, net tons,	111,500	112,000
Number of forges making wrought-iron from ore,	23	38
Annual capacity in blooms and billets, net tons,	45,000	63,000
Number of pig- and scrap-iron bloomaries,	27	37
Annual capacity in blooms, net tons,	44,000	54,000

The total of 575 blast-furnaces was obtained by adding 41 absolutely new furnaces which have been completed within the two years indicated, and subtracting 48 furnaces which have been transferred to the abandoned list for various reasons, some because they have not been in blast for several years and are badly located, and others because they have been torn down to make room for new furnaces. All the charcoal furnaces in West Virginia, and several in Pennsylvania, Maryland, Virginia, Wisconsin, and other States are among the number which have been transferred to the abandoned list. The whole number of charcoal furnaces has been reduced from 168 to 146—a net decrease of 10 in number of anthracite furnaces, which includes those which use mixed anthracite and coke, has taken place; while there has been a net increase of 25 in the number of furnaces which use bituminous coal and coke.

There has been less activity displayed in the building of new furnaces in the Northern States during the past two years, than in the Southern States. Since November 1, 1889, work has been commenced upon 10 new furnaces in the West and South: 4 at South Chicago, Illinois, 2 in Virginia—one at Graham and one at Roanoke; 2 at Middlesborough, Kentucky; 1 at Rockdale, Tennessee, and 1 at East Birmingham, Alabama; making 37 furnaces which are now building in the whole country.

Pig-iron was made in twenty-four States; rolling-mills are found in twenty-eight States and one Territory; cut-nails are made in fifteen States; wire-nails in thirteen States; Bessemer steel is made in eleven States; Clapp-Griffiths steel in three States; Robert-Bessemer steel in five States; open-hearth steel in eleven States; crucible-steel in eleven States; there are iron-ore forges in five States, and there are pig- and scrap-bloomaries in five States. The number of rolling-mills enumerated in the "Directory," which use natural gas wholly or in part as fuel, is 104, against 96 in November, 1887, 68 in August, 1886, and 6 in September, 1884.

Concerning forges and bloomaries, Mr. Swank says: "In November, 1887, there were 38 forges prepared to make pig-iron direct from ore, which number had decreased to 23 in November, 1889, New York losing 6, Tennessee 5, and Maine, Pennsylvania, North Carolina and Missouri, each losing 1. Tennessee, only a few years ago, had 23 forges making iron direct from the ore, and has but 3 forges left. In the mountainous districts of East Tennessee the forges were usually operated by farmers, who only made bar-iron from ore whenever it was needed in their immediate neighborhood. Each forge usually had two fires, with a daily production of about 250 pounds to the fire. In 1887, there were 37 bloomaries prepared to make blooms from scrap-iron and pig-iron, and in 1889 there were only 27. This, too, is a declining industry.

In 1887, the annual capacity of the iron-ore forges was 63,000 net tons, and in 1889 it was 45,000 tons. In 1887, the annual capacity of the bloomaries was 54,000 net tons, and in 1889 it was 44,000 tons. Many of the surviving forges and bloomaries are now idle.

◆

CONVERSATION ON MINES.

A LATE contribution to mining is an American reprint of an English work, entitled *Conversation on Mines*, between father and son, published by J. B. Lippincott Company, Philadelphia. Although specially devoted to coal-mining, there are many features of value to those engaged in mining iron or other ores.

The book has had a remarkable history. Its author—a hard-working coal-miner, of Lancashire, England, who had risen by natural ability and force of character to a position of trust in a mine—determined, in 1864, to issue the work, chiefly as a hand-book for the use of operatives and laborers in coal-mines. From the outset the book has had a marked success. It filled a want of the times. Its language is so clear and plain that no man of ordinary native intelligence can fail to understand it.

Its simple and exact methods of statement, its quaint and at times picturesque language, its high moral and humanitarian purpose, and the transparent honesty and unquestionable manliness and straightforwardness of its author have all helped to give the book a character of its own.

The following subjects are explained: "How Mines Generate Gases;" "Why the Discharge is Greater in One Mine Than in Another, and How Others Discharge a Mixture of Gases;" "How the Weather on the Surface of the Earth Affects the Workings of a Mine;" "The Power of Explosions, and How to Diminish it;" "Several Ways of Ventilating Mines, and How Currents of Air are propelled around the Workings;" "The Friction of the Ventilating Currents, and How to Diminish it, with Several Ways of Working Out Coal;" together with numerous questions and answers on mining matters, etc.

THE JOURNAL OF THE IRON AND STEEL INSTITUTE of Great Britain has, under the editorial care of the Institute's Secretary, Mr. J. S. Jeans, become an important component of a good metallurgical library, and improvement is noticeable in each issue. This advance is noted in Part II. of the issue of 1889, lately received; for, in addition to the papers read before the Institute which are printed, the appendices contain many facts of interest, concerning "*Iron-ores,* their Occurrence, Composition, Mining and Metallurgical Preparation," "*Refractory Materials, Fuels,* Including Coal, Coke, Oil, Gas and Their Preparation," "*Blast-Furnace Practice,*" "Analyses of Pig-Iron Slags," etc., "The Production and Further Treatment of Iron and Steel, with their Physical and Chemical Properties."

The volume is also supplied with the usual interesting statistical data concerning the iron and steel industries, and iron-ore and coal-mining of various countries.

Roll of the United States Association of Charcoal Iron Workers.

[Corrected to January 1, 1889.]

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